Physical and chemical properties of Estonian balneological peat

Mall Orru
Tallinn University of Technology, Mining Department
orru@egk.ee

Abstract

Balneological peat has physical effect through temperature and biochemical effect through bioactive substances. It is used for rheumatic diseases that are also quite common in Estonia too. Humic, Hymatomelanic, Fulvic acids, have been isolated from peat, found to be of particular importance when considering the biological effects of peat. Research show that the high quality balneological peat can be found in 7 peatlands in Estonia. The total amount of balneological peat is 920 thousand tons. The depth of peat, suitable for balneological purposes is 0.85-1.50 m. The Estonian balneological peat is ecologically clean, containing the trace elements and heavy metals, which are not hazardous for human health.

Keywords

Peat, balneology, humic substances, trace element, heavy metals

Introduction

Mire is a part of landscape where in wet condition and lack of oxygen part of the organic matter will not degrade and accumulates as peat. Peat is though an accumulation of partially decayed vegetation matter with high water content. It is a mixture of the plant parts in different decompose stages.

However, it is well known that the composition of peat in general is very complex and additionally differs depending on the source from the peat. In addition, the quality and composition of the peat is depending on many different factors as the place of origin, the primary types of the plants of origin and a whole spectrum of environmental factors (Beer et al., 2003). It shows that mineralogical-geological make-up as well as peat chemistry plays important role.

Peat and various peat preparations have been successfully used in the balneological practice of clinical medicine (Beer et al., 2006). Balneological peat as ecologically clean and natural substance is more human friendly than synthetic substances. Several European countries (Germany, Austria, Check Republic, Hungary) have long traditions of using the balneological peat. At recent decades, it is also studied and used in Finland (Korhonen, 1996).

Beer et al. (2003a) have discussed that there are many indications that also a chemical component may contribute to the clinical success of cutaneous peat treatment because several pharmacological effects have been found which cannot be contributed to the well-established physico-thermal effects.

Balneological peat has physical effect through temperature and biochemical effect through bioactive substances (Lukanov et al., 2002). It is largely used for rheumatic diseases that are also quite common in Estonia (Orru, 2009). The studies show that biochemically active humic, fulvic and hymatomelanic acids are successfully used against stress and skin diseases etc. (Beer et al., 2003). Fulvic and humic acids, all of which have been isolated from peat, have been found to be of particular importance when considering the biological effects of peat (Beer et al., 2000).

According to experience of other countries, the peat proper for balneology has to be well humified (40-50%) which natural moisture content has to be at least 85% and peat layer under the peat water level (Uosokainen, 2002).

The balneological peat has to be ecologically clean, containing the trace elements, which are not hazardous for human health (Orru, Orru, 2004). Balneological peat should complexly consist humic, hymatomelanic and fulvic acids. The ash content should be less than 12% and the thickness of proper peat layer at least 0.7 m.

Due to its composition and structure, peat has a quality to bind the trace elements (Coupal & Lasancette, 1976). The studies in Estonia has shown essential increase of concentrations of trace elements in the lower layers of peat is driven from the bedrock (Devonian sandstone in South, Dictyonema argillite in North Estonia) by the groundwater (Orru, Orru, 2006). These trace elements are the reasons for several health effects. The main mechanism that induces these negative effects is still under discussion. Recently the hypothesis of negative health effect due to oxidative properties has got much proof (Sioutas et al., 2005).

Estonian peat has not been studied from the point of balneological potentiality and researches made by author of this article in the Geological Survey of Estonia (2005-2007) are the first one in Estonia in this field. So the aim of the research was to study the amount and the quality of balneological peat. Some basic data was gathered during the research of Estonian mires what helped in scooping the study areas. The field study and laboratorial analyses were made.

The perspective of the study was to make presumptions through research to utilise domestic peat in balneology. All study areas are in state territory and the resources are available for use.
1. Materials and methods

7 study areas were chosen (Fig 1) according to the research and mapping of Estonian peatland made by Geological Survey of Estonia (Orru et al., 1992). Through fieldwork the geological routes and peat depth sounding were made. The samples were taken from the middle layers of peat, where the environmental influence is minimal.

Through geological routes the natural conditions, especially vegetation and water regime were studied in the study samples. It came out that in two peatlands (Armiko, Epa-Vassaare) the situation had totally changed due to drainage when compared to previous Orru et al. study (1992). The well humified peat was beyond the water level. More extensive studies were made in Hõreda, Kõverdama, Larvi, Oese, Parika, Sangla and Helme peatlands.

At first the thickness of proper layer, its placement and the depth of whole peat layer were sounded. Afterwards 14 peat samples were taken for determining the abundance of humic, hymatomelanic and fulvic substances and trace elements.

For determination of humic, hymatomelanic and fulvic acids in Pärnu College Laboratory University of Tartu the natural peat was extracted with 0.2 M NaOH. The humin was separated as precipitate in centrifugation, what was washed repeatedly with distilled water to separate humic substances. The humin – insoluble part of peat – was dried. Humic substances stayed in solution. The concentrated HCl was added until the pH 2, the soluble fulvic acid and insoluble humic and hymatomelanic acids were separated. The precipitation was repeatedly treated with ethanol to separate the soluble hymatomelanic acid and insoluble humic acid. Both fractions where dried. The fulvic acid solution was cleaned through XAD-7 gum for desalination. In treatment of gum with 0.1 M NaOH the pure fulvic acid fraction was separated, what was carried through acidic form with ion exchanger IR-120. The gathered fraction was dried.

8 samples where analysed in Biotech OY laboratory in Finland. The peat was dried and mineralised with HCl and HF acids in pH value 0.7. The filtration and precipitate washing with 0.1 M NaOH followed. pH was regulated with 1 M HCl. Subsequently it was centrifuged and concentration of fulvic and humic acids where measured.

The content of 34 trace elements where analysed in the laboratory of Geological Survey of Finland. Sample was dried and chopped. Peat was decomposed with nitric acid. The content of elements was analysed with following methods:

- IPC-MS method – As, Ag, B, Ba, Be, Bi, Cd, Cr, Cu, Li, Mo, Ni, Pb, Rb, Sb, Se, Sr, Th, Ti, U, V, Zn;
- IPC-AES method – Al, Ca, Fe, K, Mg, Mn, Na, P, S, Si, Ti;
- sulphur analyser – the content of sulphur.

2. Results

2.1. Chemical properties of peat

The study showed that the depth of the balneologically usable peat layer is 0.85-1.50. If it is less than 0.7 m, it is technically and economically difficult to use. Then the layer can be separated in mining and one can be sure that the peat comes from the right depth interval. In all study areas the peat is positioned in the middle of the whole peat layer. In that layer the peat is the least affected by atmospheric pollution, anthropogenic activities and entry of trace element from bedrock with groundwater and springs. There, the abundance of trace elements was lower than average concentrations in Estonian peatlands (Orru, Orru, 2006).

Paragraph about trace elements in peat

Also figure (see Fig 2), where several elements and their content in these peatlands and also average contents in Estonian peatlands from Orru, Orru, 2006 analyses.
Table 1. Characteristics of research areas.

<table>
<thead>
<tr>
<th></th>
<th>Genesis of peat deposit</th>
<th>Mineral subsoil</th>
<th>Vegetation</th>
<th>Nutrition</th>
<th>Depth of peat layer</th>
<th>Peat type</th>
<th>Degree of humification</th>
<th>Ash content</th>
<th>pH</th>
<th>Moisture content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hõreda</td>
<td>Lake paludification</td>
<td>Sand-clay, sand</td>
<td>Pine forest</td>
<td>Precipitation 0.60-1.70</td>
<td>Cottongrass, pine-cottongrass peat</td>
<td>45-50</td>
<td>2.1</td>
<td>4.4</td>
<td>86</td>
<td></td>
</tr>
<tr>
<td>Kõverdama</td>
<td>Paludification</td>
<td>Clay-sand</td>
<td>Pine forest, mosses</td>
<td>Precipitation 1.30-2.80</td>
<td>Heath-sphagnum, heath cottongrass peat</td>
<td>40-45</td>
<td>4.5</td>
<td>4.55</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>Larvi</td>
<td>Lake paludification</td>
<td>Gyttja-sand</td>
<td>Pine forest, mire</td>
<td>Precipitation 0.50–1.35</td>
<td>Cottongrass, cottongrass-sphagnum peat</td>
<td>40-45</td>
<td>3.2</td>
<td>4.7</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>Oese</td>
<td>Lake paludification</td>
<td>Gyttja-sand</td>
<td>Pine forest</td>
<td>Precipitation 0.75–1.60</td>
<td>Heath-cottongrass, pine-sphagnum peat</td>
<td>40-50</td>
<td>4.9</td>
<td>5.1</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Parika</td>
<td>Lake paludification</td>
<td>Sand</td>
<td>Pine forest</td>
<td>Precipitation 0.70–1.60</td>
<td>Pine-sphagnum, forest-cottongrass peat</td>
<td>50</td>
<td>2.8</td>
<td>4</td>
<td>87</td>
<td></td>
</tr>
<tr>
<td>Sangla</td>
<td>Basin paludification</td>
<td>Gyttja-sand</td>
<td>Pine, birch, mire</td>
<td>Precipitation 0.70–2.00</td>
<td>Heath-sphagnum, heath-cottongrass peat</td>
<td>40-45</td>
<td>4.8</td>
<td>4.8</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>Helme</td>
<td>Basin paludification</td>
<td>Sand</td>
<td>Open mire</td>
<td>Precipitation 0.50–1.40</td>
<td>Wood-cotton-grass, cottongrass sphagnum peat</td>
<td>40-45</td>
<td>1.8</td>
<td>3.3</td>
<td>90</td>
<td></td>
</tr>
</tbody>
</table>

Fig 2. Samples

2.2. Balneological properties

The peat suitable for balneological purposes is mainly well humified (40-50%, von Post 6-8) raised bog peat. As for peat types cottongrass-sphagnum, cottongrass, wood-cottongrass, heath-cottongrass peat are more represented. All areas in peatlands where the balneological peat can be found are in natural virgin mire condition. The water level is 0.3-0.6 m beneath the ground level so the moisture content (85-92%) is bigger than the minimum required value (85%) (Table 1).

The laboratorial analyses showed that in all studied layers humic, hymatomelanic and fulvic acids can be found and are good for human organisms due to their healing properties (Fig 3,4). Most of these substances can be found in Kõverdama, Parika, Hõreda and Larvi peatlands. The research shows that if these compounds occur complexly in peat they are effective for treatment of arthritic, gynaecological, skin etc. diseases and stress (Korhonen, Lüttig, 1996). The abundance of humic substances in Estonian peat is high (up to 60%).
Fig 3. The content of humic, hymatomelanic and fulvic acids. Analyses made in the Pärnu College Laboratory University of Tartu

* Pure fulvic acid, where during the analysis low molecular fractions and soluble salts are separated

Fig 4. The content of humic and fulvic acids. Analyses made in CRS - Biotech OY in Finland during cooperation between Geological Surveys of Estonia and Finland

*The content of humic acid consists also hymatomelanic acids what wasn’t measured separately

** The fulvic acid consists also low molecular fraction and soluble salts

### 3. Discussion

#### 3.1. Balneological properties

The impact of humic substances on the quality of human heath in increasingly recognized as an important subject of future research work.

Investigations of humic substances aimed at the molecular structure and mechanism of action encompass specialized investigations within such diverse fields as physical, analytical, environmental and food chemistry, cell biology, molecular genetics, pharmacology and toxicology (Klöcking, Helbig, 2005).

#### 3.2. Trace elements

The chemical composition of peat depends on a number of factors like: feeding conditions of mire, geomorphologic position, geological setting of region, environmental conditions, and anthropogenic impact. The feeding conditions has the main impact – the highest concentrations of trace elements were observed in the middle and bottom layers of a peat deposit feeding from groundwater.
4. Conclusions

Research show that the high quality balneological peat can be found at least in 7 peatlands in Estonia. The total amount of balneological peat is 920 thousand tons, what is distributed in different mires as follows:

- Höreda in 22 ha 47 thousand tons
- Köverdama in 94 ha 226 thousand tons
- Larvi in 14 ha 25 thousand tons
- Oese in 12 ha 22 thousand tons
- Parika in 73 ha 113 thousand tons
- Sangla in 151 ha 466 thousand tons
- Helme in 12 ha 21 thousand tons.

Through peatlands the depth of the peat suitable for balneological purposes is 0.85-1.50 m. The moisture content is 85-92% what more than minimal required 85%.

The balneological peat can be found mainly as raised bog peat fed mainly from precipitation. In all studied and sampled peat layers the humic, hymatomelanic and fulvic acids, which are good for human organism with healing properties, were found.

It was determined that the content of bioactive substances in sampled layers is high and the content of trace elements is lower than on average. The balneological peat could be used cosmetically and for sauna peat. It is suitable for use in rehabilitation hospitals, SPA-s and domestic treatment.

Before starting to use Estonian peat for balneological purposes the effect of bioactive substances on human organism should be verified in control group. This is the main aim of further research.

5. Acknowledgements

This research was supported by the Estonian Environmental Foundation. Author would like to thank Monika Übner from Pärnu College, University of Tartu, Hans Orru from Department of Public Health for scientific consultation and support.

References