

# Balneology in Estonia: importance of the geochemical background information of the Estonian curative mud

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## Introduction

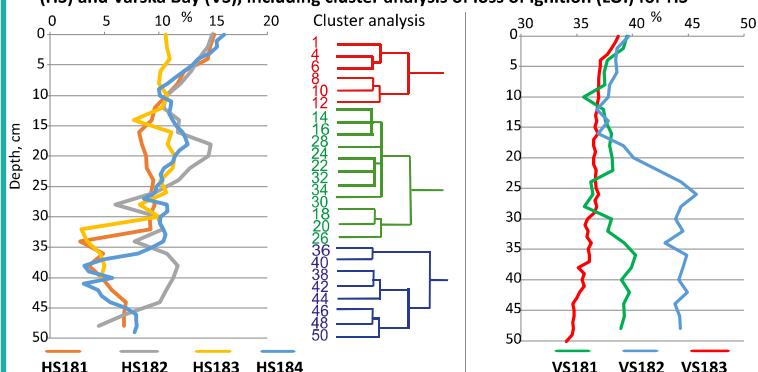
Estonia has the most significant resources for health and wellness tourism among the Baltic countries, including Scandinavia. In Estonia, natural remedies were commonly used during the first half of the 19th century, and frequently contained mud and sea-water (Schlossmann 1939). However, the scientific understanding of the functions of the ecosystems that provide the benefits to human societies is still limited. Since there are no specific standards regarding the bio-geo-chemical composition of curative mud, only the different geochemical and bioactive compound groups could be identified. Internationally, the terminology is not uniform, and relevant inconsistencies are found in the scientific literature regarding both nomenclature and the definition of terms used in health resort medicine or spa therapy, balneology, balneotherapy, mud therapy, pelotherapy, etc. (Gomes et al. 2013). Curative mud research in Estonia has stagnated since the 1990s, and one of the main limiting factors to the redevelopment of its public and commercial use is a lack of up-to-date scientific understanding about the sediment composition and depositional characteristics.

## Methods

- A total of 145 surface samples (2013–2014) and 7 sediments cores (2017–2018)
- Thermogravimetric analysis (TGA)
- Energy-dispersive X-ray fluorescence spectrometry (ED-XRF) (PANalytical–Epsilon 3)
- PAH analyses ISO 18287:2006 (Estonian Environmental Research Centre Lab)

## Results

### Organic matter content for the sediment cores of Haapsalu Tagalaht Bay (HS) and Värskla Bay (VS), including cluster analysis of loss of ignition (LOI) for HS



### Polycyclic aromatic hydrocarbons (PAH) in the curative mud of the Haapsalu Tagalaht Bay and balneological peat

PAH	Haapsalu	Balneo peat	HELCOM GES*
antratseen	0.013	0.005	0.085
benzo(a)püreen	0.053	0.027	0.430
benzo(b)fluoranteen	0.077	<0.005	–
benzo(g,h,i)perüleen	0.070	<0.005	0.085
benzo(k)fluoranteen	0.069	<0.005	–
fluoranteen	0.140	0.008	0.600
indeno(1,2,3-cd)püreen	0.110	<0.005	0.240
naftaleen	0.011	0.010	0.160

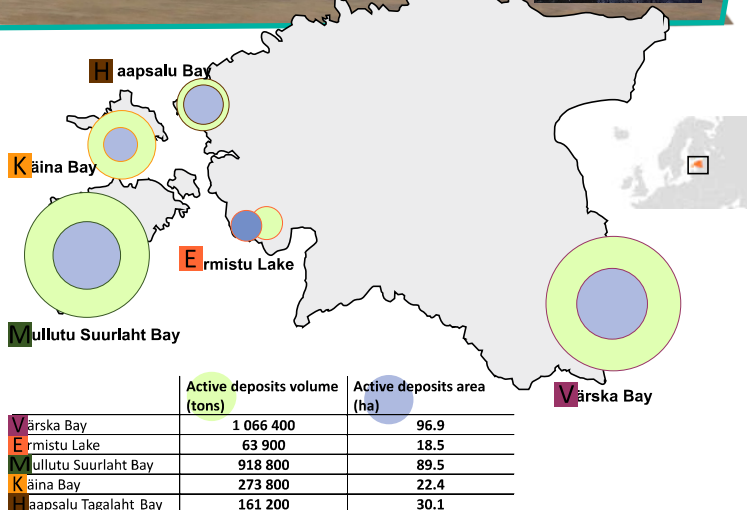
\* as a comparison, the assessment of the environmental status of mud in the Gulf of Finland, the PAH values as a good environmental status (GES) recommended by HELCOM (Eesti Geoloogiakeskus et al., 2016)

All of the heavy metal data from Haapsalu Bay (except for Sr) showed a statistically significant correlation with the organic matter, mineral and carbonate components. In Mullutu-Suurlaht Bay, there was no link between the spatial distribution of heavy metals and organic matter, but they did correlate with both the mineral and carbonate components. In Värskla Bay, there was no relationship between lithology and the heavy metals. In Käina Bay, there were some statistically significant correlations for individual heavy metals. This demonstrates the high spatial variability of LOI, which is, to some extent, due to the different ecosystems – lake vs. sea or maritime coastal lake. The weakest relationship between lithological composition and heavy metals was represented by the organic-matter-rich lake muds.



## Conclusions

- The existing deposits of Estonian curative mud represent more than 3.3 million tonnes, of which only 5% are used.
- The concentrations of potentially toxic heavy metals do not exceed target limit values (based on comparison to Estonian soil standards), although some exceeded heavy metal guidance limit value levels (considered to be the limits for healthy soil conditions).
- The distribution patterns of PAHs are indicative of contributions from a mixture of petrogenic and pyrolytic profiles, which are at least eight times lower than the HELCOM GES limit value for good environmental status.
- The curative mud deposits show temporal variability. The organic matter content in the lake deposits has remained about the same, or has slightly decreased. A trend in the sea sediments towards increased organic matter content, however, reflects an ecological deterioration, with an increase in the amount of algae and vegetation. If such change continues, it could put at risk the future quality, and possible utility, of the curative mud. Additional investigation is needed to address this.
- The curative mud is usually viewed as a separate service, but its use has a long tradition, and it actually serves a therapeutic, as well as a significant cultural, service.



### Heavy metals concentration (average, ppm) in the mineral deposits of the Estonian curative mud

