ACID SULFATE SOILS

Arctic Smartness RDI-Excellence tutkijaseminaari
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ACID SULFATE SOILS

- Naturally occurring soils that contain iron sulfide minerals (FeS, FeS$_2$)
- In undisturbed conditions (below water table) pose no risk or low risk
- When disturbed (drained, excavated or exposed to air) react with oxygen and form sulfuric acid and toxic quantities of aluminium and other heavy metals
- Human activities are the main cause for oxidation
THE ORIGIN OF ACID SULFATE SOILS

- Formed in Finland after the last glaciation during Litorina Sea stage
- formed by bacterial activity in waterlogged conditions in (reducing conditions)
- Naturally occurring bacteria used organic material (decaying vegetation) converted sulfate from seawater into iron sulfides
Sediments deposited in water - sea bottom, shallow bays, river deltas

Nowadays found in in river valleys, low coastal areas, arable and forest lands, below peat

In Finland found mainly in coastal areas, occasionally also inland in bottom of lakes and also in black shist areas

Mainly below 60 m a.s.l. but in Northern Finland found also ~ 80 – 100 m a.s.l.
GLOBAL DISTRIBUTION

- GTK’s international contacts
  - Australia, Poland, Sweden, Denmark, Norway

- GTK is leading an international Acid Sulfate Soils working group in 2018 - 2020

Ljung et al. 2009
ENVIRO\n
Oxidation → Release of sulfuric acid → release of metals
Autumn rain / spring floods → acidness and metals release into surface waters
killing vegetation, acidifying groundwater and surface water bodies, killing fish and other aquatic organisms

pH 3.2
EFFECTS ON INFRASTUCTION

Corrosion of concrete and steel constructions
Bad geotechnical qualities → land masses and their proper handling (burying, neutralization), stabilizing, embankment

E75 road construction site
Sulfidic sediments in 2 m depth
pH < 4 after incubation
AGRICULTURAL IMPACTS

Low pH causes low productivity, increases need of liming (short effect)
Precipitation of Fe and Al into drainage systems
GTK has been mapping the occurrence of acid sulfate soils since 2009

- General map 1:250 000
- Completed by 2021

Target scale mapping for peat production areas and town planning

Some latest projects

- EAKR SULFA II 2016-2019
- EAKR Tunnistus 2017-2020
- CBC Kolarctic HazArctic 2019-2022
FIELDWORK, SAMPLING AND ANALYSES

- Drilling to 2-3 meters depth
- Soil observations: soil type, colour, texture
- Sampling: every soil layer
- pH measurements (field & incubation)
- S and metals from selected samples
PH INCUBATION

The soil material is classified based on pH

Criteria for acid sulfate soils
- Mineral soil: pH < 4.0
- Organic matter: pH < 3.0

Oxidation in room temperature for at least 8 weeks.
Maastokäyttöisten tunnistusmenetelmien kehittäminen happamille sulfaattimaille (TUNNISTUS)

- Development of field-based identification methods
  - Development of quick identification methods and quality control
  - To evaluate the suitability for field conditions
  - To recognize and evaluate the risk of oxidation

- Methods now used are time-consuming and expencive, recognition in field is not certain
TUNNISTUS - IDENTIFICATION

• Hydrogen peroxide oxidation (< 1 day)
  • pH < 2.5
• ”Power” incubation (1 week)
  • 30 °C temperature, thin sample layer (2mm)
• EC
  • Strong correlation, not yet a limit value
• Laboratory and field XRF
Toimintamallit happamuuden ennakoimiseksi ja riskien hallitsemiseksi turvetuotantoalueilla

The operational models to predict acidness and manage risks in peat production areas

GTK’s tasks

- to prepare guidelines for mapping acid sulfate soils in peat production areas
- To study the protective effect of peat thickness
HAZARCTIC

- Geo-Bio Hazards in the Arctic Region
- GTK, LuKe, NGU, SGU, GI KSC ja MI KSC
- The project studies areal extension, mechanism and risk for oxidation in both anthropogenic (mining areas) and natural environments (acid sulfate soils)
  - Acid sulfate soils (mapping and predictive modelling development, acid rains, mining environments (Montsegorsk), geomicrobiology
FUTURE WORK?

- Digital Soil Mapping (Predictive Soil Mapping) – to analyse and map soil properties using statistical computation (R-language) (HazArctic and KLIVA)
- Acid sulfate soils ”service”
  - To provide sampling planning, fieldwork, detailed mapping, fast identification, analyzes, risk evaluation, modelling, guidelines