LIFE12 ENV/FI/000592 UPACMIC -
Utilisation of by-products and alternative construction materials in mine construction

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LIFE12 ENV/FI/000592

PROJECT OVERVIEW

- EU funded project, started in 2013, estimated end date 2020-2023.
- Project partners: Ramboll Finland (coordinator), Suomen maastorakentajat, Fortum Environmental Construction
- Area: secondary materials in mining sector

➢ Initial problem: Mine closure consumes high volumes of aggregates. Meanwhile, many industries produces suitable waste material for earth construction

RAMBOLL

PROJECT TARGETS

- **Development and piloting of suitable alternative material mixtures for:**
  - **Cover layers**
  - **Bottom sealing layers**
  - **Reactive barriers**
- **Monitoring of the impact of the project actions**
  - **Evaluation of the results from environmental and technical monitoring**
  - **Best practices learned from the project are put together into the guideline**
- **Piloting has been carried out in Pyhäsalmi and Hitura mine in Finland**

By-products from various industries

Waste gypsum

Fibre clay (deinking sludge)

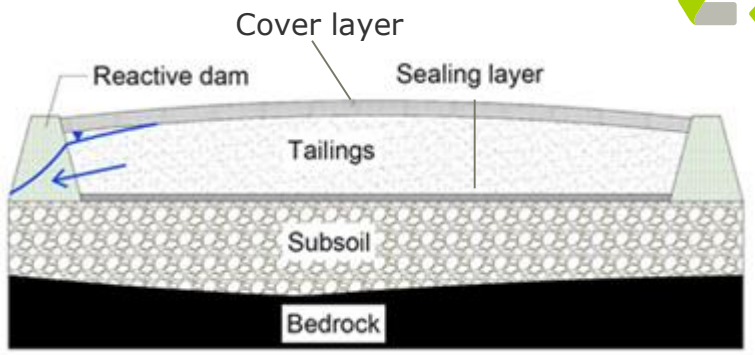
Biomass fly ash

Waste lime

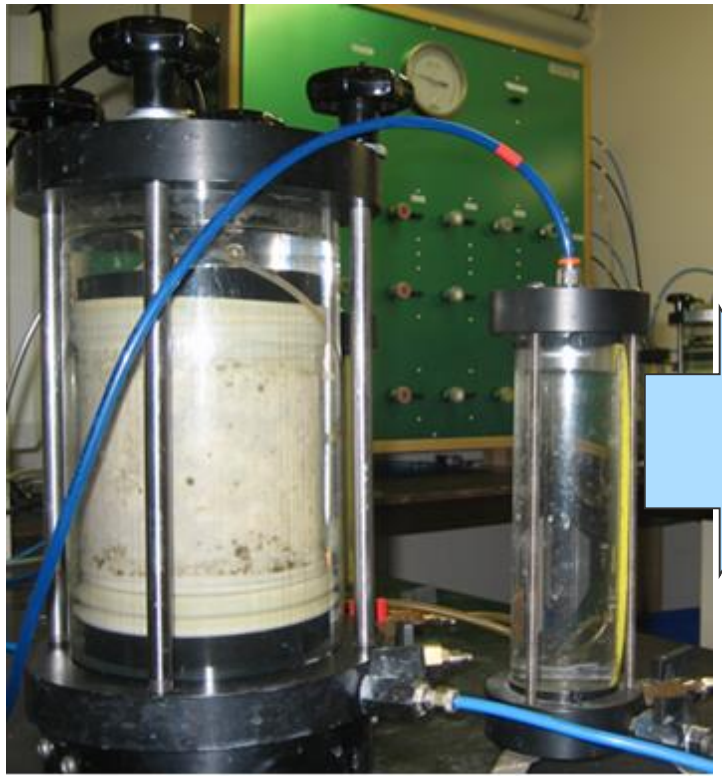
Anaerobic digestion residue

Foundry sand

New materials for mine construction



DESIGNING PROCESS



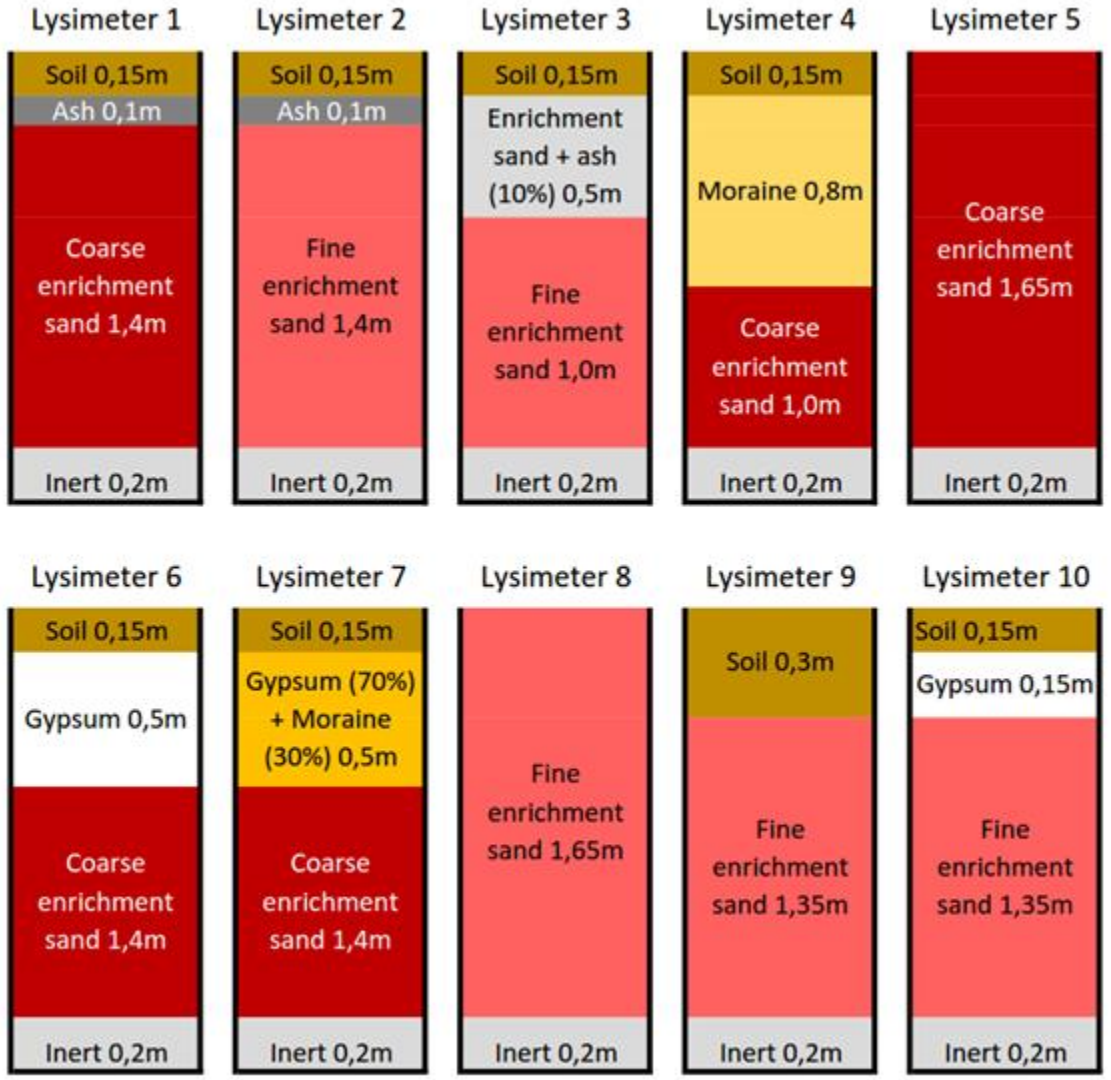
LABORATORY TESTING AND DESIGNING

PILOT TESTING IN FIELD CONDITIONS
- PYHÄSALMI MINE
- HITURA MINE

PILOT CONSTRUCTION
- HITURA MINE

LYSIMETER TEST IN PYHÄSALMI, MATERIALS

- 5 different cover layer structures were tested for both coarse and fine enrichment sands
- Tested cover structure alternatives were selected based on preliminary laboratory results
- Fly ash was used for neutralising purpose
- Gypsum waste was selected for the tests because of its good availability (1,5 milj. tons produced annually).



LYSIMETER TEST IN PYHÄSALMI, MATERIALS

- Enrichment sand consists mainly on sulfide minerals (pyrite, baryte and pyrrhotite) and smaller amounts (<5%) of silicate minerals e.g. plagioclase, quarz and olivine
- Some burnt lime have been added to enrichment sand after the enrichment process to prevent the acid generation
- Moraine was sieved (<60mm) local moraine from Pyhäsalmi
- Gypsum waste used in the test was from phosphor acid producing fertilizer plant
- Fly ash used in the test was from nearby power plant

Total concentrations and material properties of the used construction materials

Material	Al (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)	Ca (mg/kg)	S (mg/kg)	pH (-)	ρ_d (kg/m^3)
Enrichment sand (fine)	7180	680	297000	590	1680	25400	294000	7,0	1870
Enrichment sand (coarse)	6910	720	315000	430	2180	20700	310000	6,7	2380
Ash	52400	120	142000	2430	240	72100	12800	9,5	830
Gypsum	340	13	400	21	20	277000	215000	2,8	1290
Moraine	12800	55	17500	240	63	5040	350	4,8	2300
Inert material	11000	20	20800	190	33	6570	210	7,5	-

MATERIAL SOLUBILITIES (2-STAGE BATCH LEACHING TEST)

Material	Sulfate (mg/kg)	Chloride (mg/kg)	Fluoride (mg/kg)	Al (mg/kg)	As (mg/kg)	Ba (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	Hg (mg/kg)	Mn (mg/kg)	Mo (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Sb (mg/kg)	Se (mg/kg)	V (mg/kg)	Zn (mg/kg)	Ca (mg/kg)
Moraine	280	<50	<5	0,94	<0,15	0,43	<0,015	<0,1	0,2	0,68	<0,005	5,8	<0,05	0,12	<0,15	<0,01	<0,02	<0,05	2,1	49
Gypsum	17500	<50	2190	4,1	1,5	0,06	0,049	<0,1	4,3	35,3	<0,005	17	<0,05	0,47	<0,15	<0,01	0,031	0,11	20,9	6620
Fly ash	16600	924	<5	110	<0,15	1,00	<0,015	0,5	<0,1	<0,15	<0,005	<0,1	3	<0,1	<0,15	<0,01	0,067	0,1	<0,1	6100
Coarse enrichment sand	17300	<50	6	<0,3	<0,15	0,21	0,11	<0,1	<0,1	<0,15	<0,005	54	<0,05	0,42	<0,15	<0,01	0,023	<0,05	21	6410
Fine enrichment sand	18100	<50	6,1	<0,3	<0,15	0,19	0,054	<0,1	<0,1	<0,15	<0,005	38	<0,05	0,21	<0,15	<0,01	0,02	<0,05	11	6390
Inert material	<50	<50	<5	0,63	<0,15	0,093	<0,015	<0,1	<0,1	0,56	<0,005	0,063	<0,05	<0,1	<0,15	<0,01	<0,02	<0,05	<0,1	15

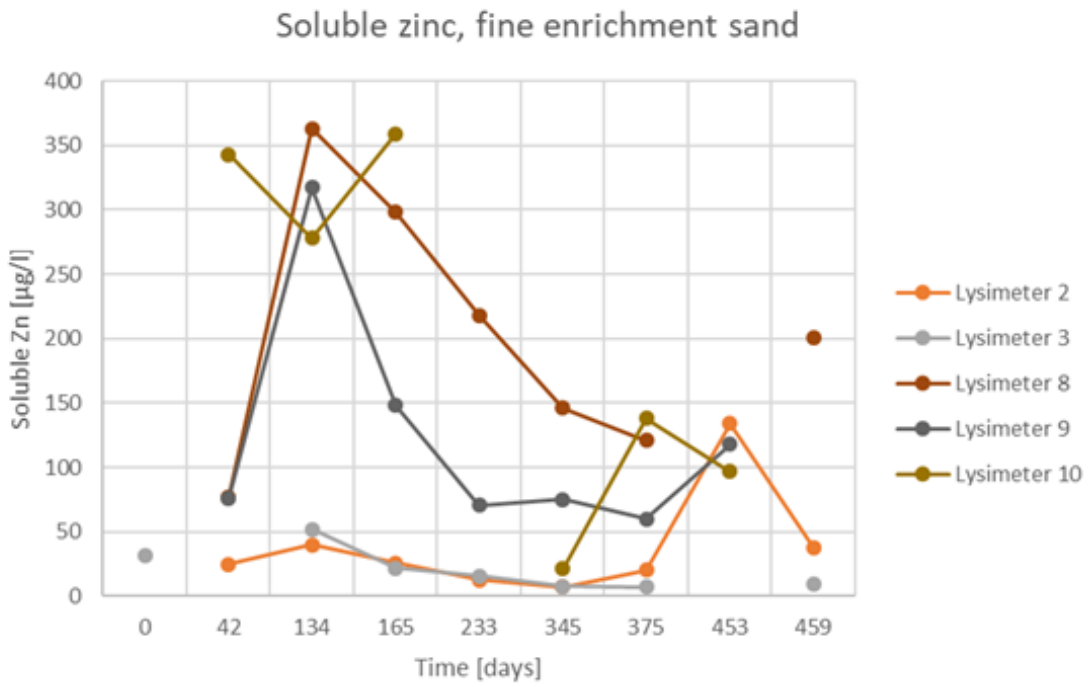
RAMBØLL

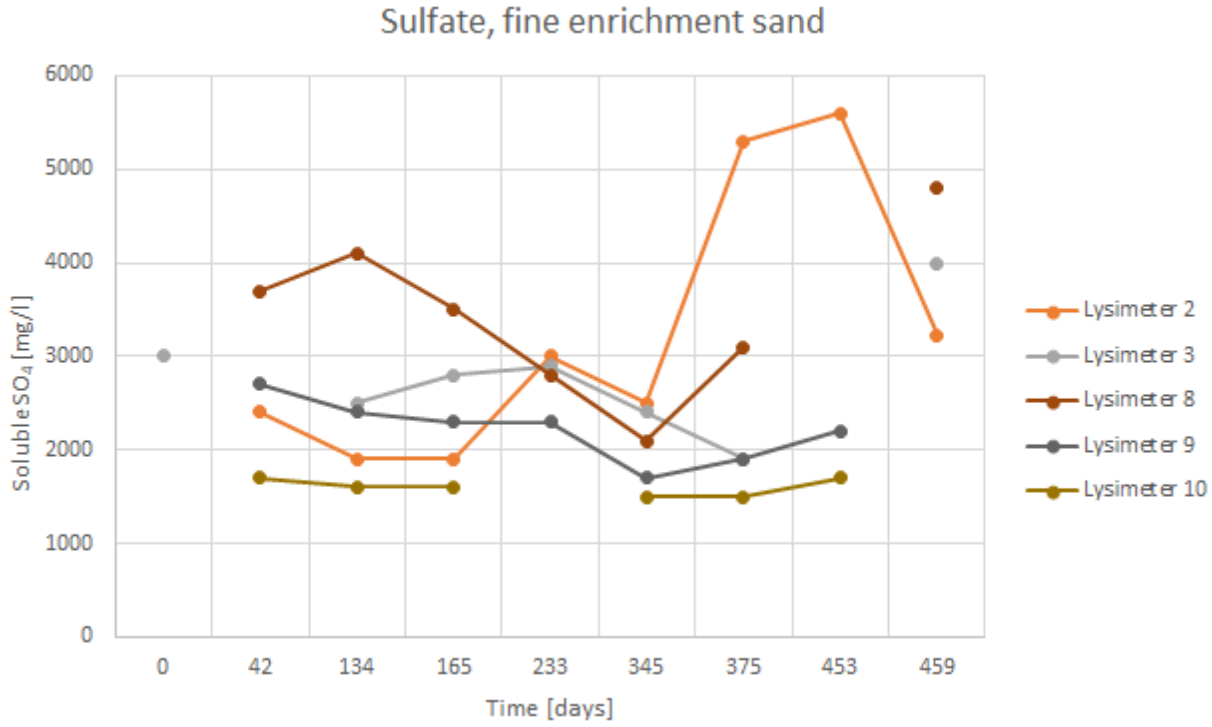
LYSIMETER TESTS, SETUP

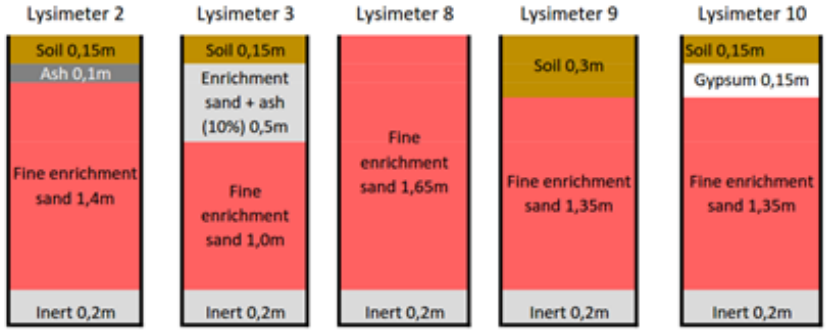
- Tests monitoring period was 5/2016-8/2017
- The quality of the seepage water was monitored after 42, 134, 165, 233, 345, 375, 453/459 days. Samples were collected in one week period from lysimeter wells
- Al, As, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Sb, Se, V, Zn, Ca, K, Mg, Na and S (µg/l) and also for sulfate, fluoride, chloride and DOC (mg/l) was measured from the water samples.
- Of which **Cu**, **Zn**, **Fe** and **sulfate** were main interest
- The amount of seepage water was monitored weekly

Lysimeter installation

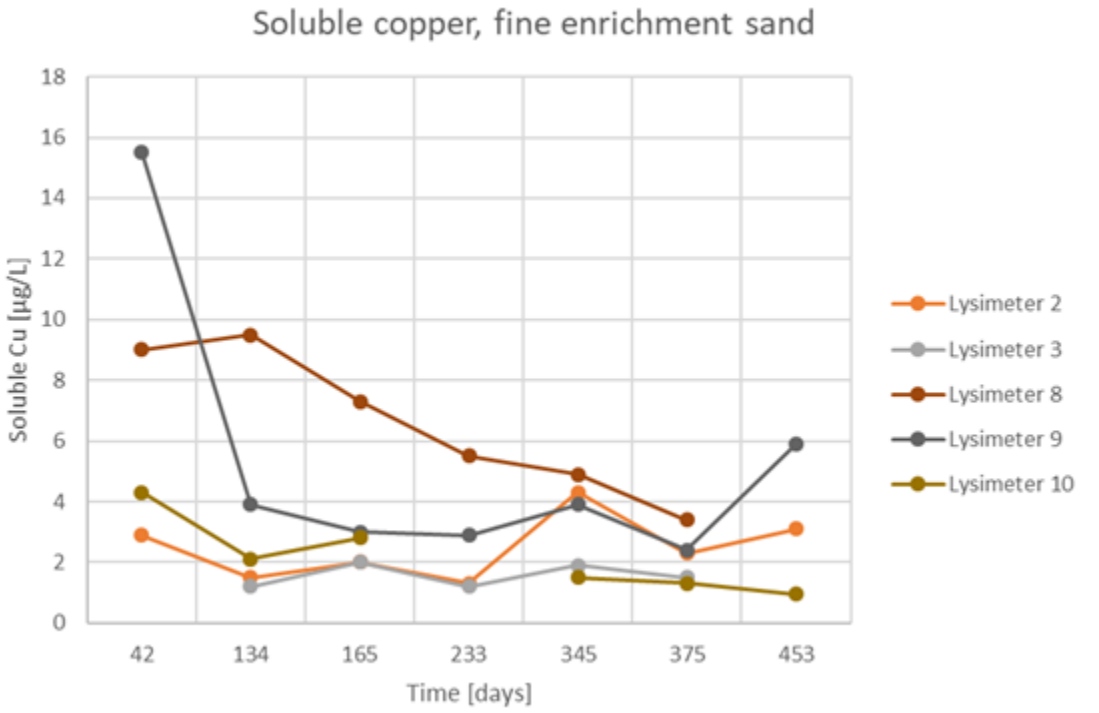
LYSIMETER TEST, FINE ENRICHMENT SAND RESULTS

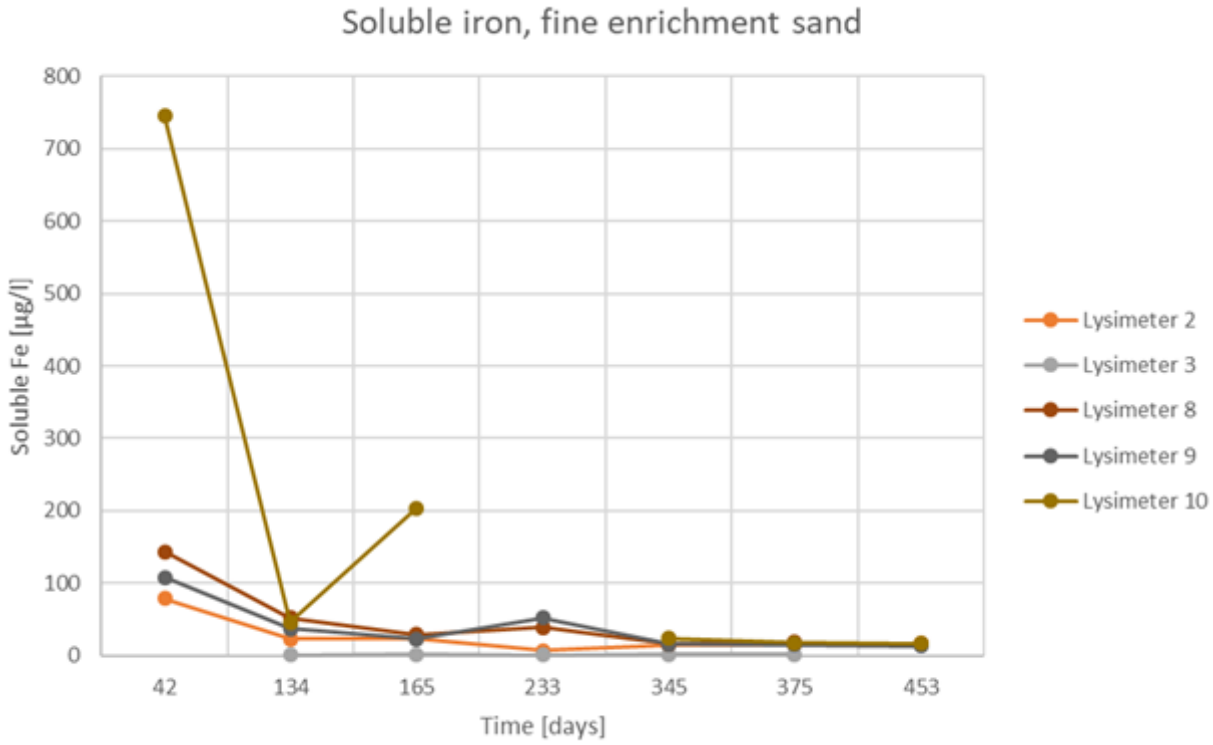


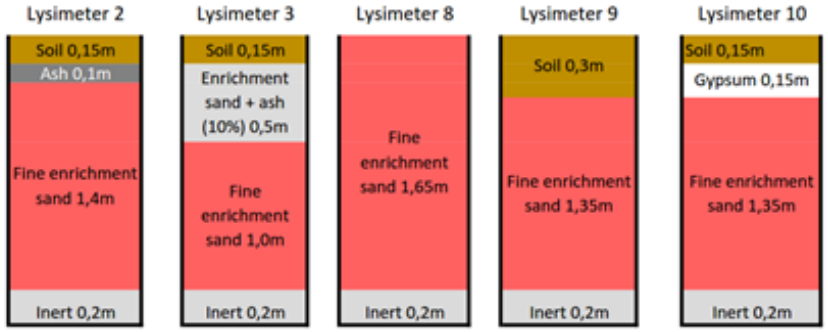




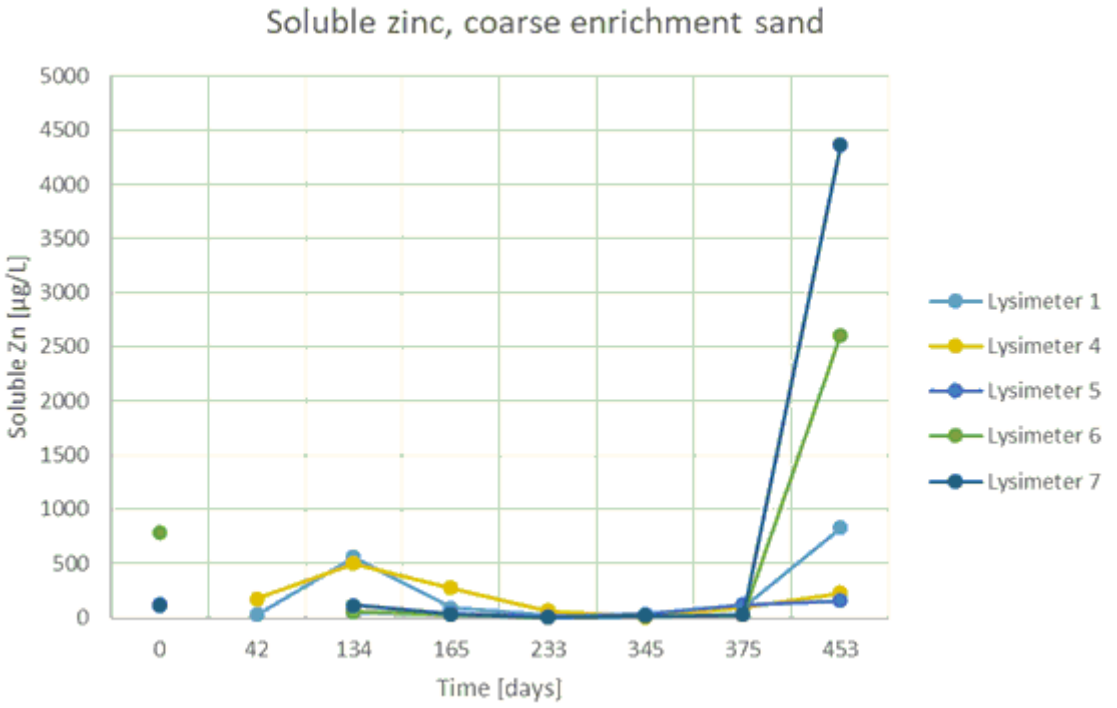
LYSIMETER TEST, FINE ENRICHMENT SAND RESULTS

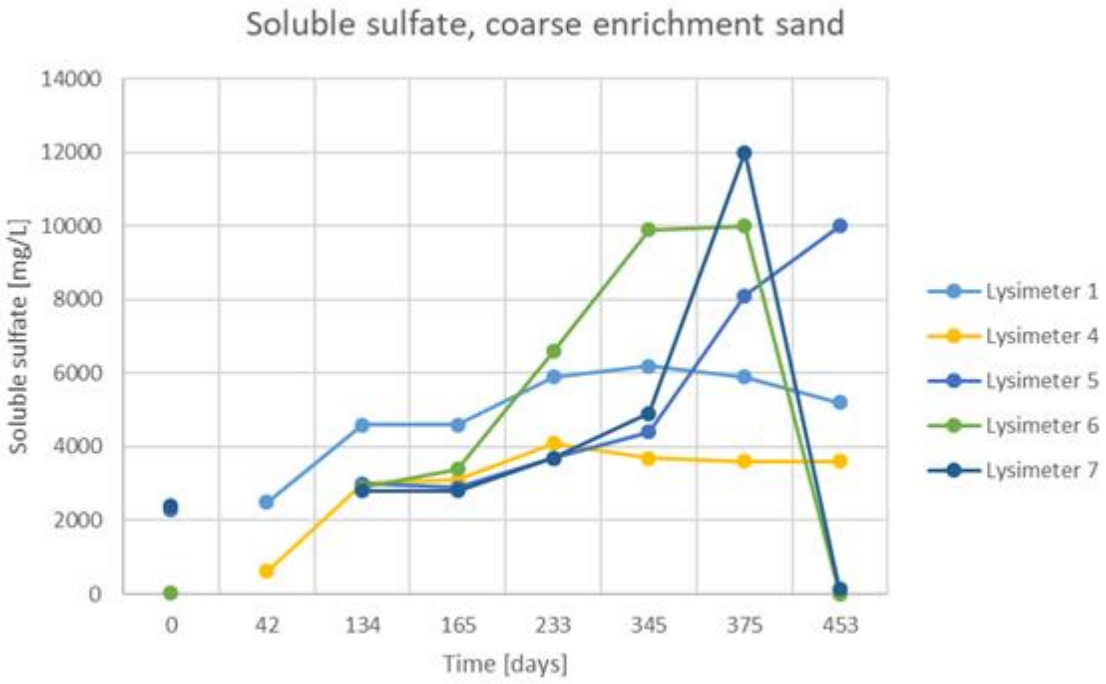


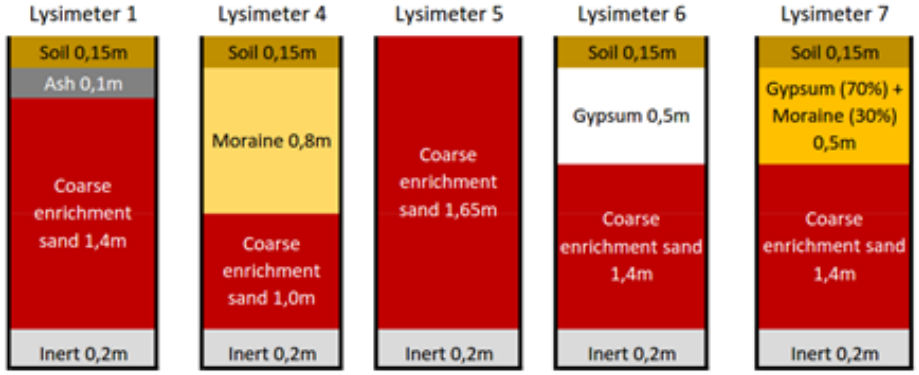




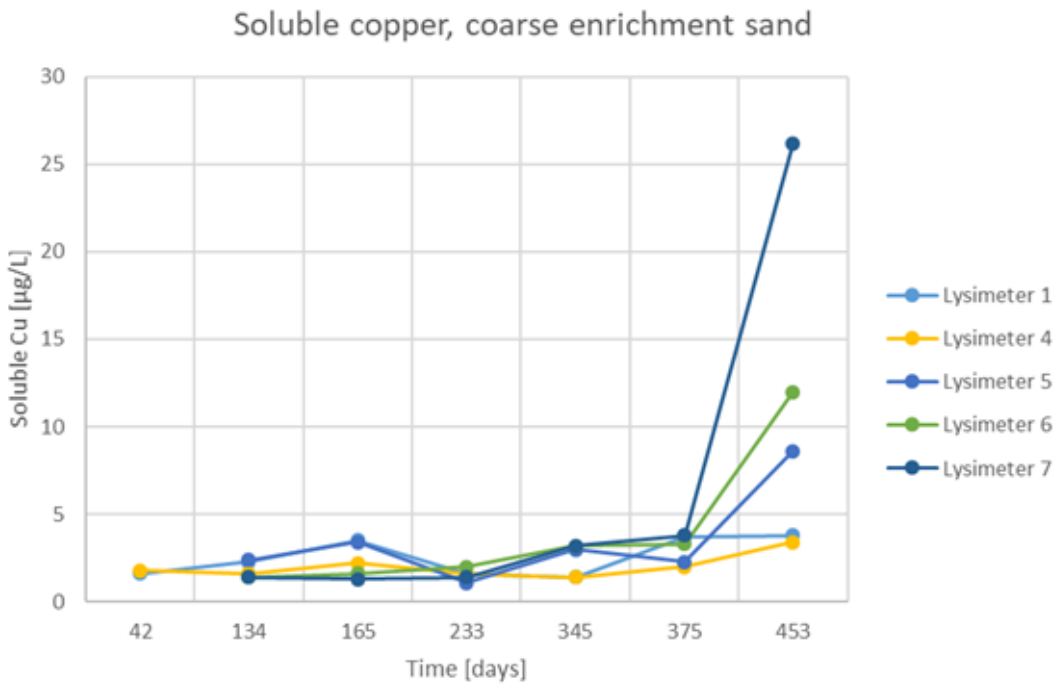
LYSIMETER TEST, COARSE ENRICHMENT SAND RESULTS

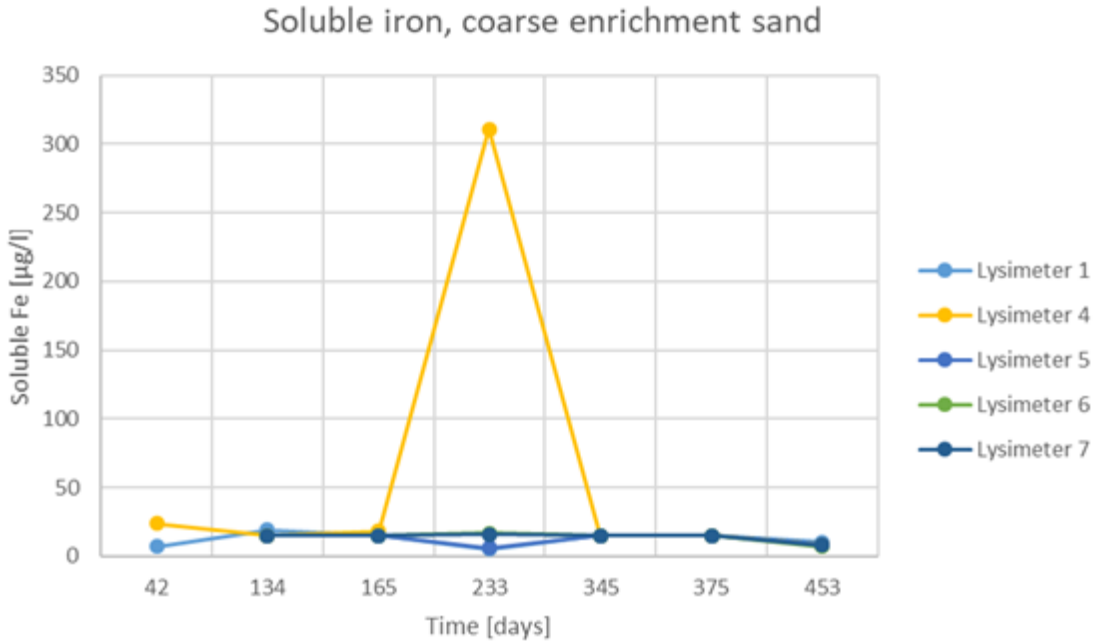


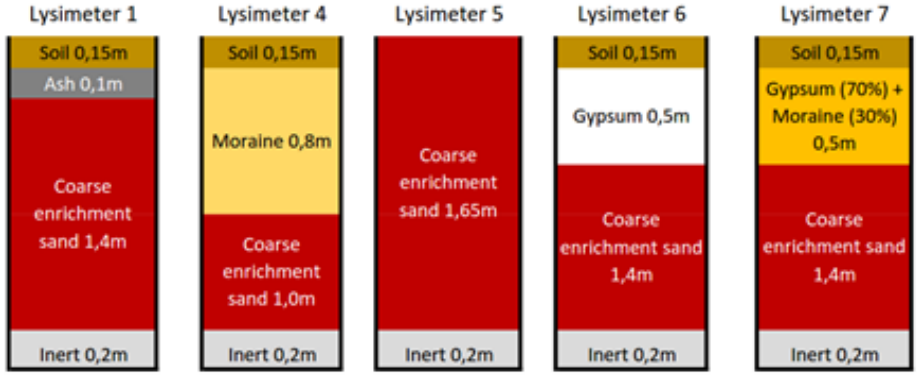




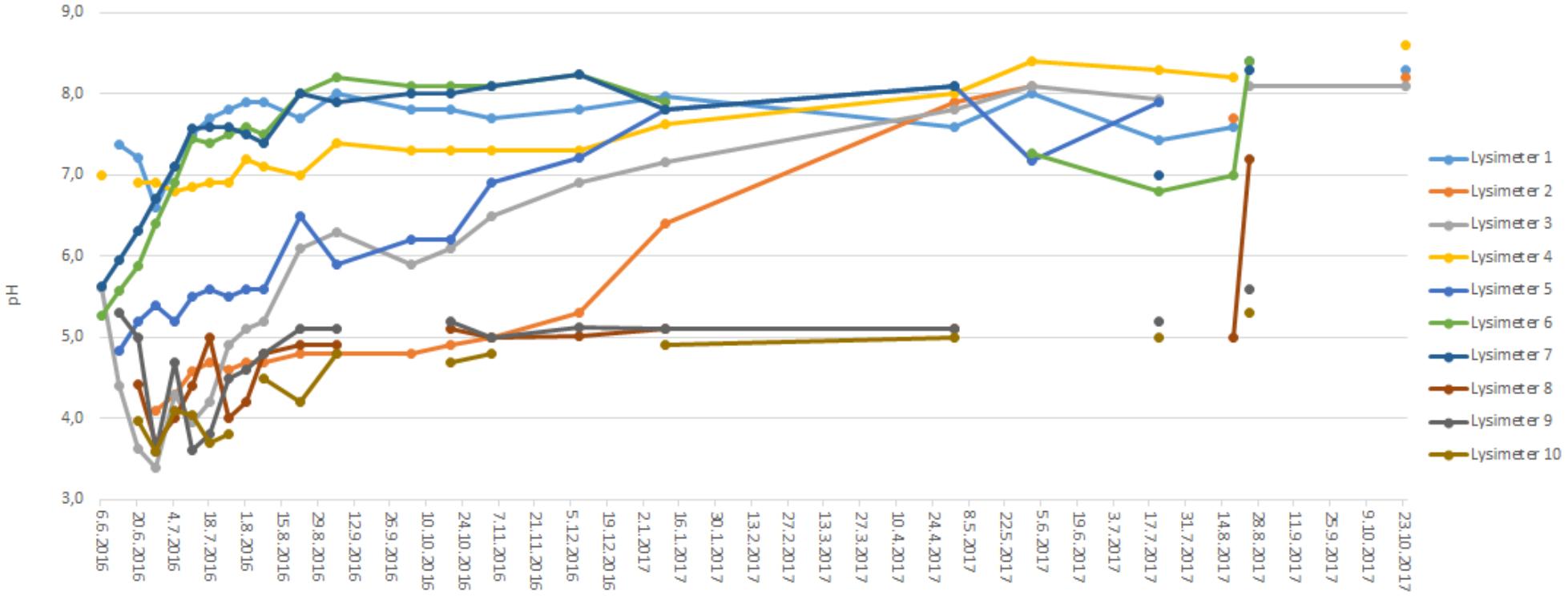
LYSIMETER TEST, COARSE ENRICHMENT SAND RESULTS



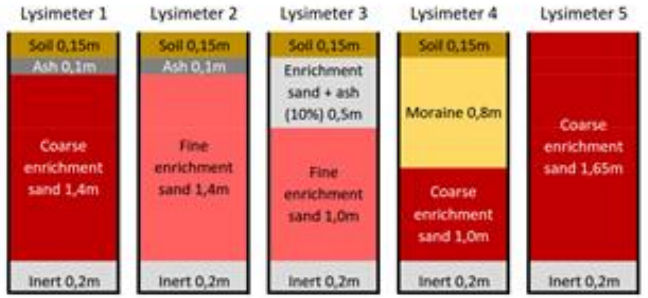


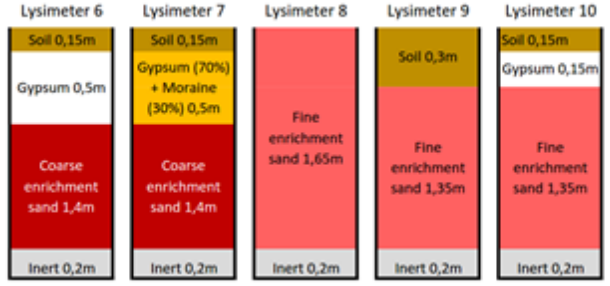


PH MEASUREMENTS

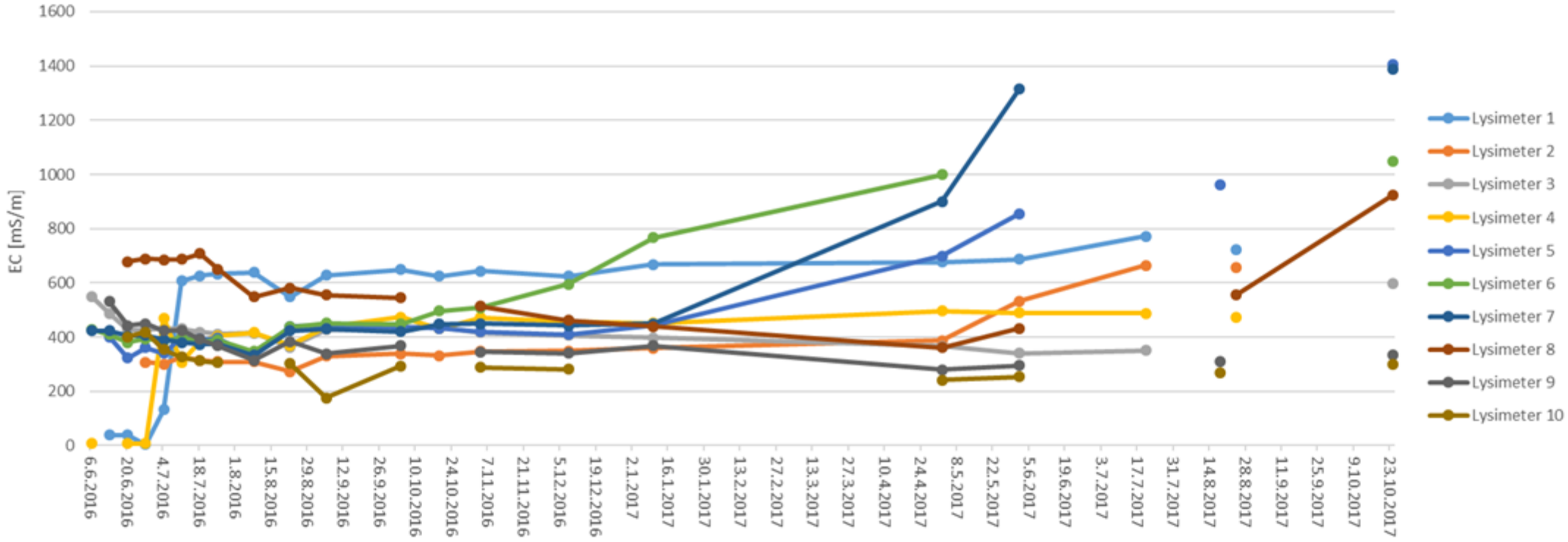


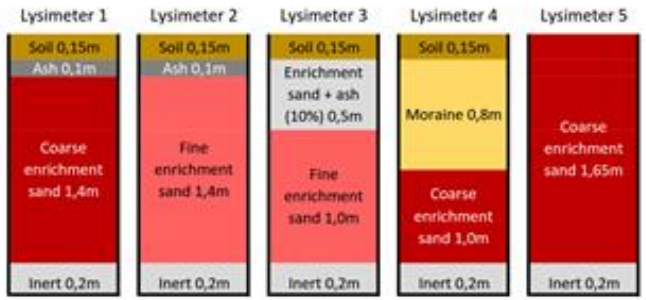
Average pH
7,7
5,8
6,0
7,5
6,5
7,3
7,4
5,2
4,9
4,5

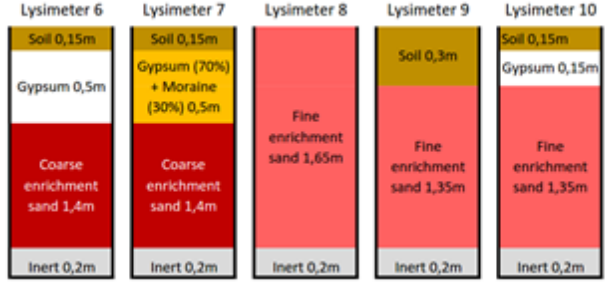




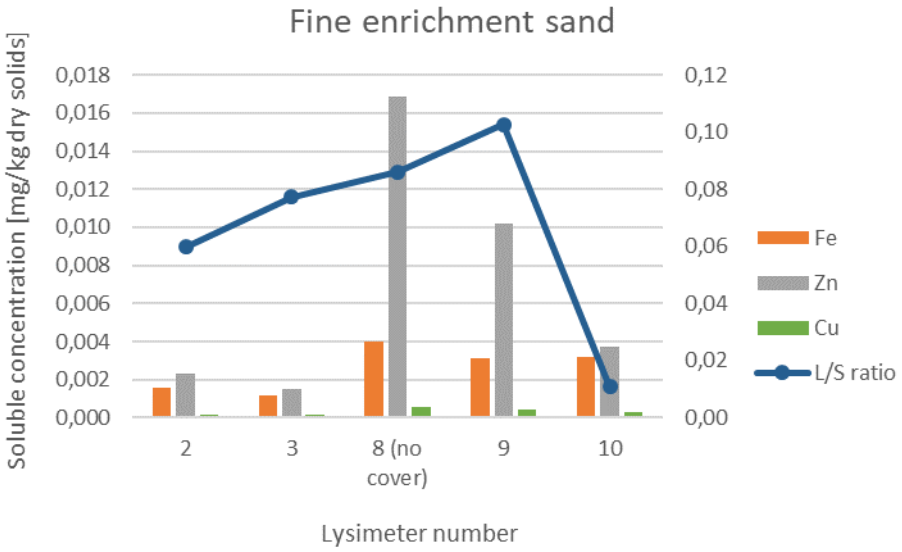
EC MEASUREMENTS

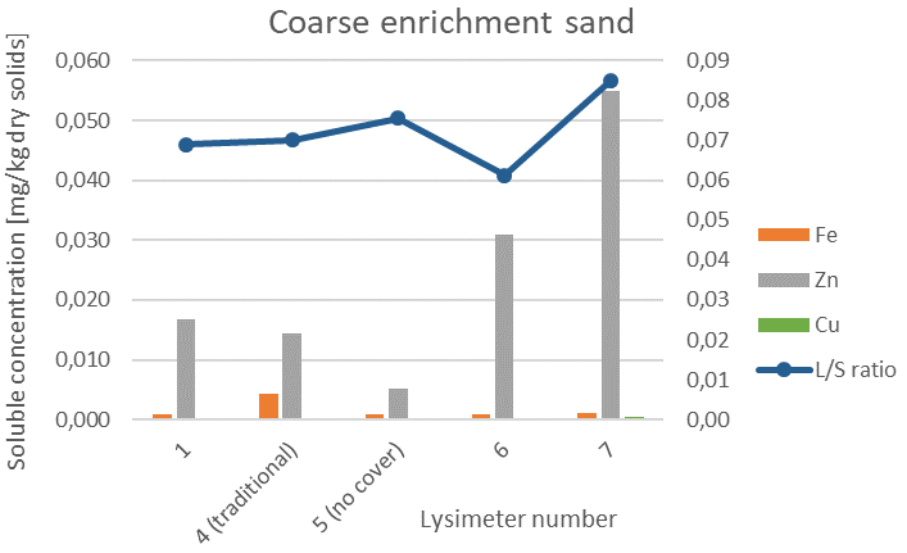


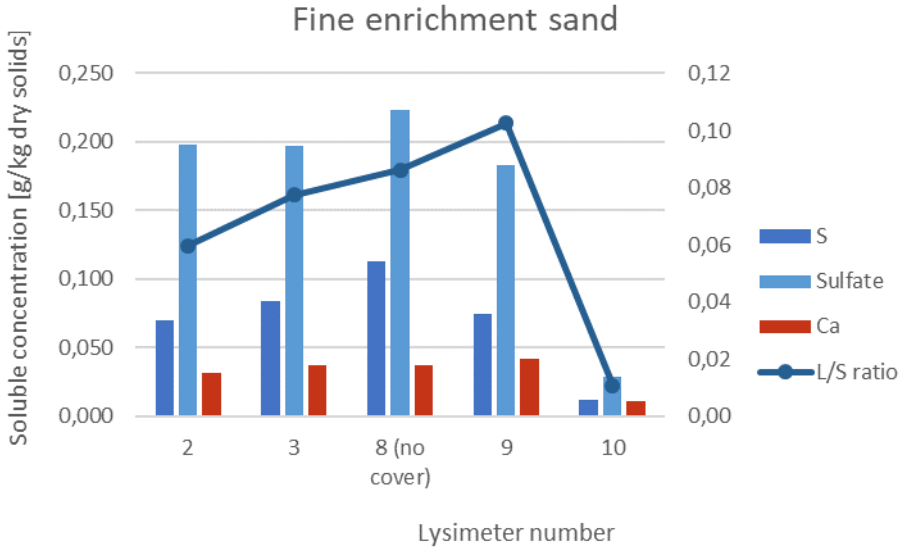


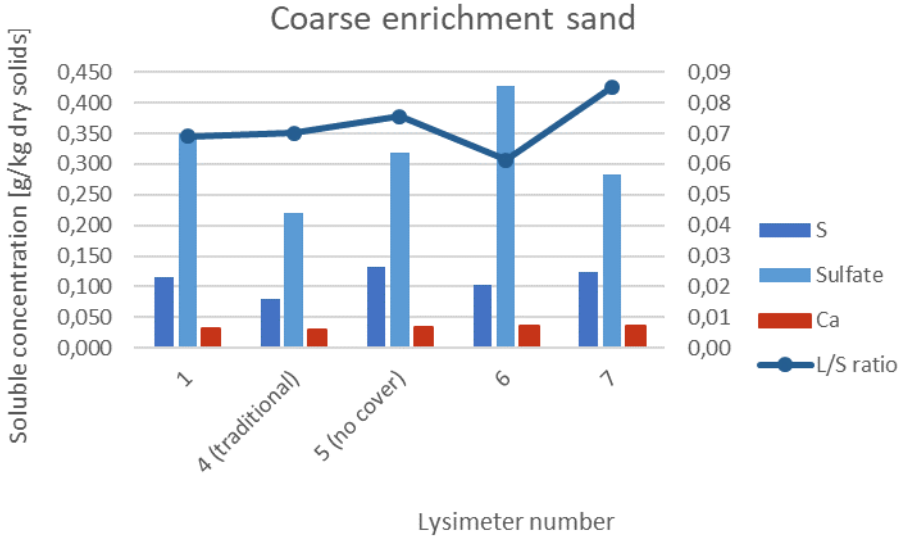


SOLUBILITY RESULTS ON A DRY MATTER BASIS









Lysimeter no.	Cumulative seepage water (l)	Dry solids (kg)	L/S ratio
1	996	14153	0,07
2	781	12733	0,06
3	1120	14065	0,08
4 (traditional)	1047	14090	0,07
5 (no cover)	1168	15370	0,08
6	739	10930	0,06
7	1043	14430	0,09
8 (no cover)	1273	15345	0,09
9	985	11900	0,10
10	248	13760	0,01

CONCLUSIONS AND SUMMARY OF THE LYSIMETER TESTS

- Difference between coarse and fine enrichment sands (weathering)
- Fly ash cover increases pH and seems to lower (at least) Al, Cu, Zn and Fe solubilities compared to other cover structures.
- Fly ash cover showed lower leachability compared to gypsum cover
- Sulfate leachability was about the same level for all tested cover structures
- Overall, EC and metal leachabilities showed increasing trend which can refer to weathering of enrichment sands. Long term behaviour?

- Uncertainties: relatively short monitoring time, variations in L/S ratio, sampling done only from certain time periods (not from mixed samples)

RAMBOLL

THANK YOU!

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Project website:

http://projektit.ramboll.fi/life/upacmic/index.htm