Monitoring and controlling nitrogen load originating from explosives

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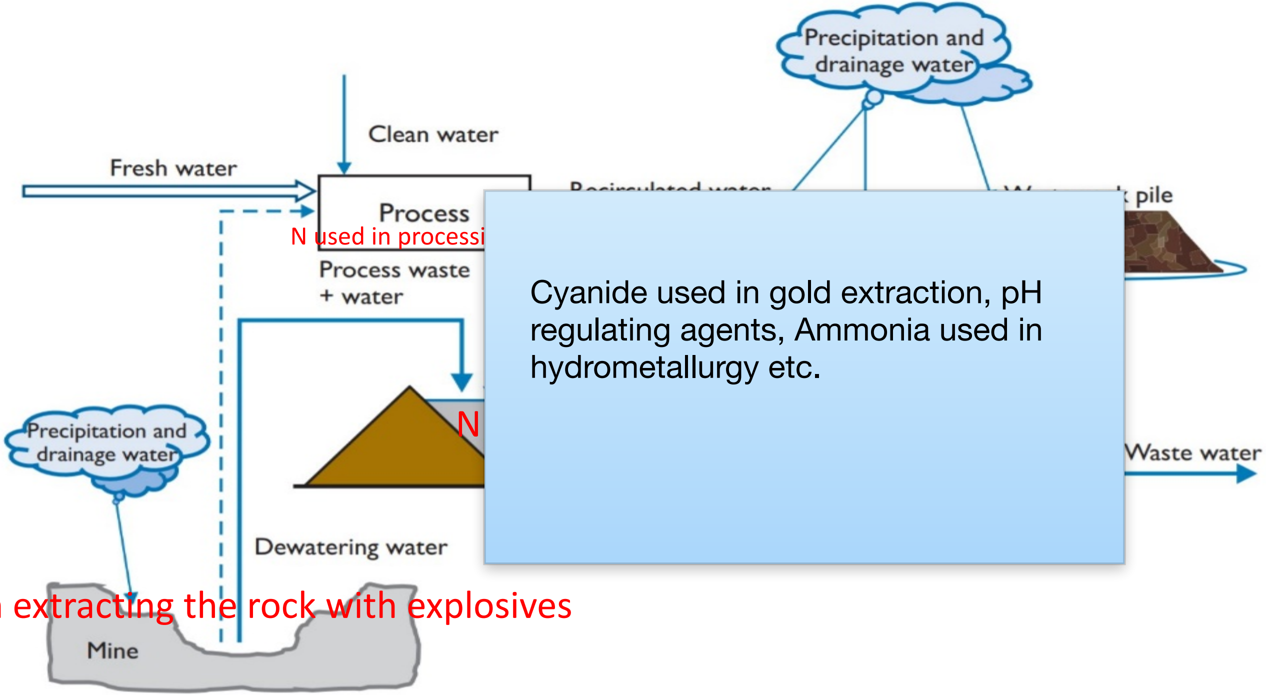
WaterPro closing seminar 22.5.2019

N runoffs caused by mining operations



Cyanide used in gold extraction, pH regulating agents, Ammonia used in hydrometallurgy etc.

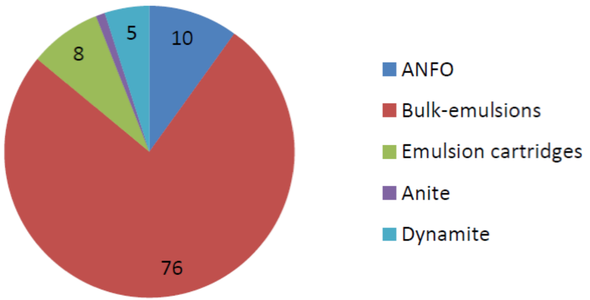
Modified from Kauppila et al. 2011

Figure 14. Example of the traditional pattern of water use at a mine (fresh water = surface water taken from a nearby natural source. Clean water = tap water).

N originating from explosives

- In ideal explosion ammonium nitrate converts to nitrogen, water and oxygen and fuel converts to carbon dioxide and water: $3NH_4NO_3 + CH_2 \rightarrow 3N_2 + 7H_2O + CO_2$
- Emulsified explosives usually release cleaner gases and less nitrates to the water compared to traditional explosives (e.g. ANFOs).
- Total consumption of explosives is around 50 000 t/a in Finland, around 25% of the mass is nitrogen
- 16–28 % of the N used in natural stone blasting is leached into the surrounding water system

Share (%) of explosive types used in Finland, 2011



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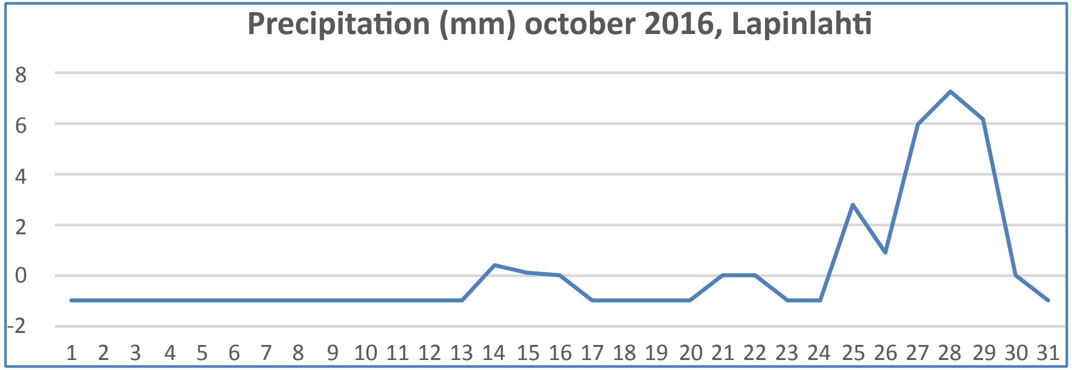
Part 1 - monitoring the leaching of explosive remains during October 2016

- Juuka, soapstone quarry (12.9-28.9.2016)
- Lapinlahti, anorthosite quarry (3.10-3.11.2016)
- Blasting day 6.10.2016
- Emulsified explosive, Kemiitti ~18 000 kg (includes ~4500 kg nitrate)



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Sampling site
"putki"
Sampling site
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Rautapuro

HyXo Oy
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DR 2800
LCK 304 Ammonium
690 nm
Negatiivinen tulos!
-0.009
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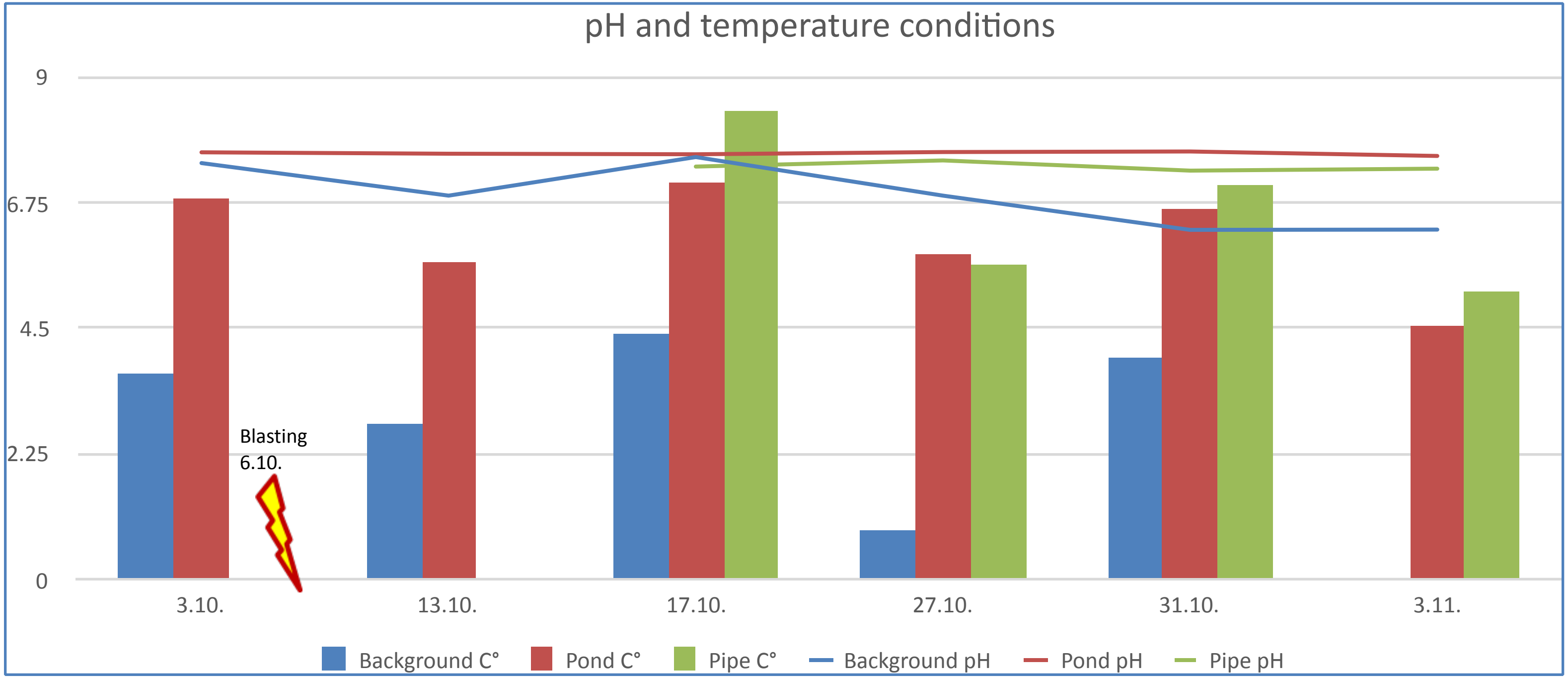
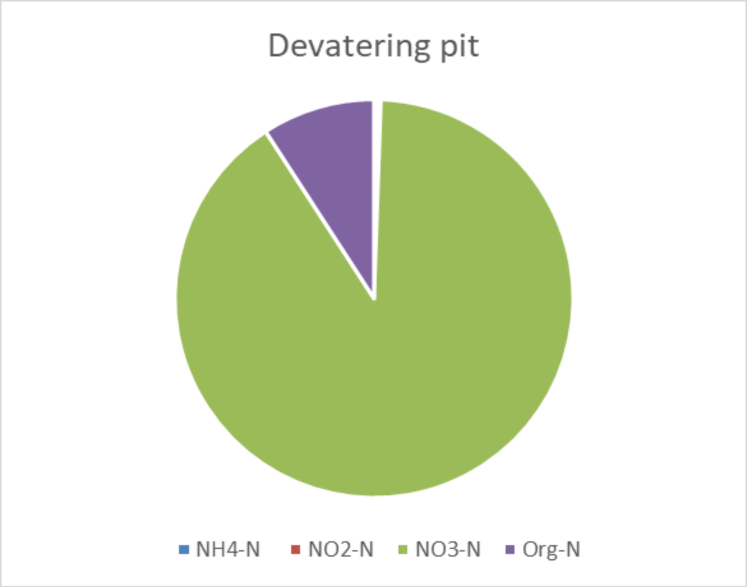
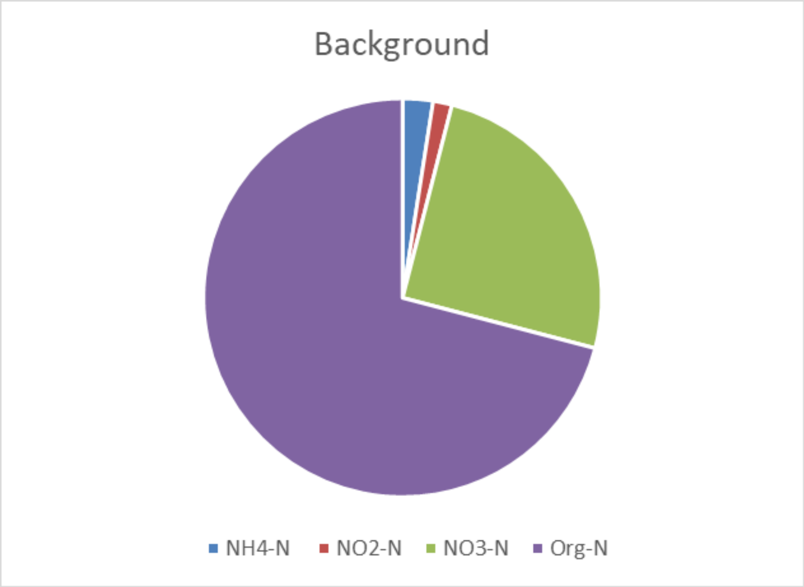
Research plus


pH and temperature conditions
9
6.75
4.5
2.25
0
Blasting
6.10.
3.10.
13.10.
17.10.
27.10.
31.10.
3.11.
Background C°
Pond C°
Pipe C°
Background pH
Pond pH
Pipe pH

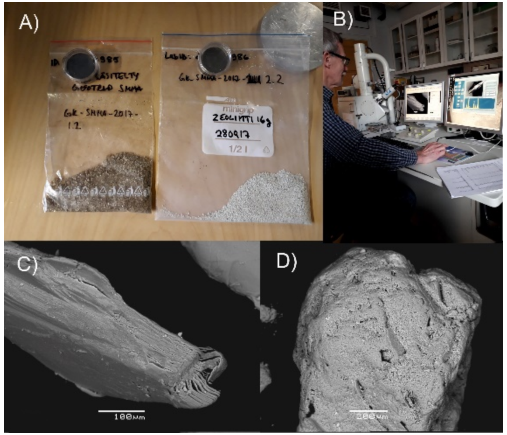
The form of nitrogen in the drainage water and in the background





Part 2 – removal of nitrogen from waste water with mineral adsorbents

- Vermiculite and zeolite were applied as mineral adsorbents
- Water tested was ammonium and nitrate-rich wastewater collected from an industrial site
- Influence of contact time, adsorbent dose, pH and temperature on ammonium and nitrate removal were studied using a jar-tester



Ammonium and metal removal from waste water using different dose of vermiculite as adsorbent

	NH_4^+	Al	Ba	Ca	K	Mg	Mn	P	S	Zn
				mg/l						
Detection limit	2	0.2	0.02	0.5	0.5	0.1	0.02	0.1	0.1	0.02
Untreated wastewater	427	2.1	<0.02	213	77.2	45.2	1.77	8.1	165	1.63
4 g of vermiculite, 1 h	406	0.3	0.05	250	76.6	50.2	1.71	8.2	196	1.32
4 g of vermiculite, 20 h	353	0.2	0.08	290	77.4	59.8	1.62	5.9	179	0.36
8 g of vermiculite, 1 h	365	0.4	0.10	291	75.3	55.1	1.64	8.0	196	1.18
8 g of vermiculite, 20 h	274	0.3	0.15	352	74.2	71.2	1.47	5.7	177	0.28
16 g of vermiculite, 1 h	314	0.6	0.19	348	71.7	61.9	1.53	7.8	193	1.05
16 g of vermiculite, 20 h	205	0.5	0.29	451	69.5	93.5	1.23	5.5	177	0.21
32 g of vermiculite, 1 h	229	0.7	0.34	464	66.6	75.7	1.37	7.6	195	0.77
32 g of vermiculite, 20 h	200	0.6	0.45	583	60.0	125.0	0.87	5.0	176	0.12

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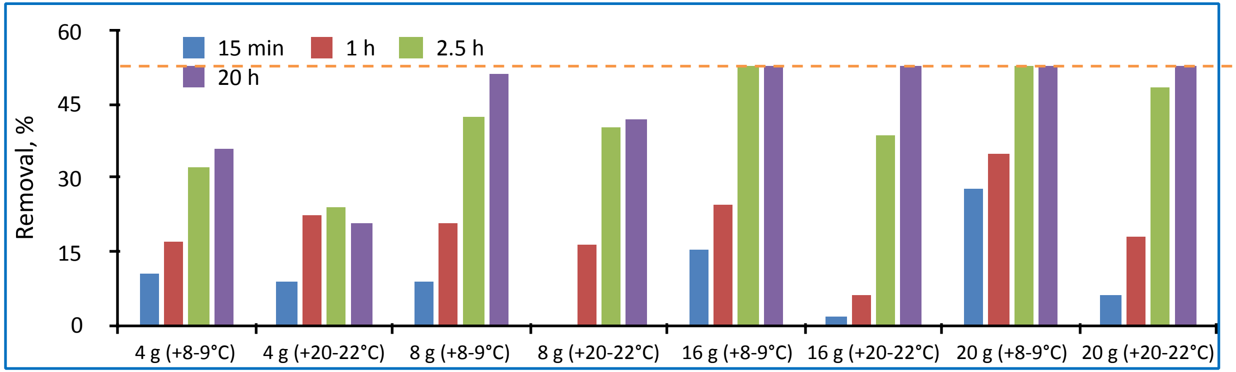
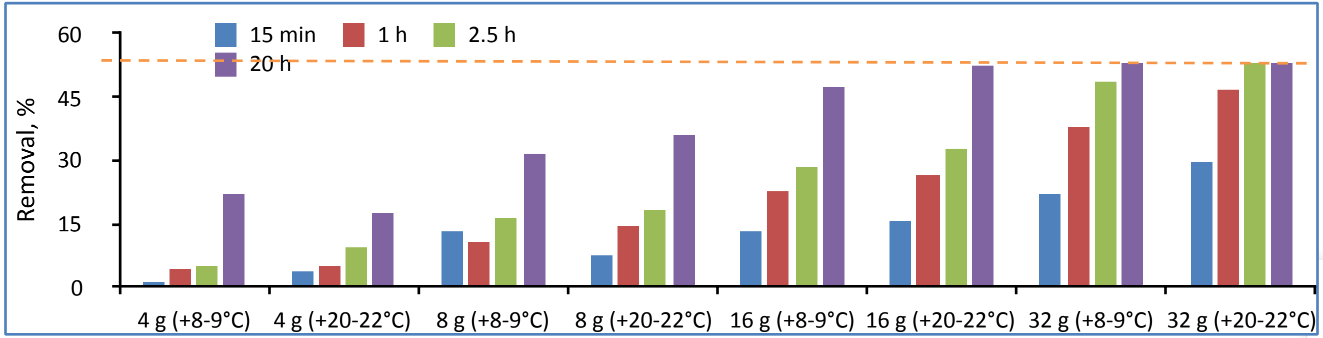
… removal from waste water using … e as adsorbent

			Ba	Ca	K	Mg	Mn	Na	P	S	Zn
					mg/l						
[illegible]	[illegible]	[illegible]	0.02	0.5	0.5	0.1	0.02	0.5	0.1	0.1	0.02
[illegible]	[illegible]	[illegible]	<0.02	186	70.6	42.7	1.57	20.9	7.5	170	1.79
4 g of zeolite, 1 h	430	0.5	0.02	196	69.6	43.4	1.54	107	4.8	174	1.19
4 g of zeolite, 20 h	401	0.3	0.09	212	69.5	45.4	1.47	131	4.3	173	0.54
8 g of zeolite, 1 h	356	0.5	0.04	200	65.6	43.9	1.49	183	4.9	175	1.15
8 g of zeolite, 20 h	349	0.2	0.10	227	63.9	47.3	1.39	225	4.4	174	0.40
16 g of zeolite, 1 h	256	0.5	0.06	206	58.5	44.5	1.42	316	4.8	175	1.01
16 g of zeolite, 20 h	221	0.2	0.07	244	52.3	48.8	1.22	385	4.5	178	0.28
20 g of zeolite, 1 h	248	0.5	0.06	212	54.8	45.2	1.40	381	4.9	177	0.97
20 g of zeolite, 20 h	200	0.2	0.06	244	47.2	49.1	1.14	453	4.7	177	0.20

Removal of ammonium at different temperature using various doses of zeolite



Removal of ammonium at different temperature using various doses of vermiculite



*detection limit of LCK 303 is 2 mg/l what corresponds to 53% of ammonium removal

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Conclusions

- Monitoring revealed increasing of the nitrogen content in the quarry drainage water after the blasting event. Nitrogen was mainly in the form of nitrate.
- Tested adsorbents significantly reduced ammonium concentration and removed selected metals from the wastewater in the study
- Both adsorbents were capable to remove ammonium effectively under various process conditions - temperature change influenced the process efficiency while the pH changes had a minor effect on ammonium adsorption.
- Tests showed that vermiculite and zeolite adsorb various metals, thus utilization of spent adsorbents as fertilizer is questionable -> recovering nutrients is safer from metal free wastewater

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