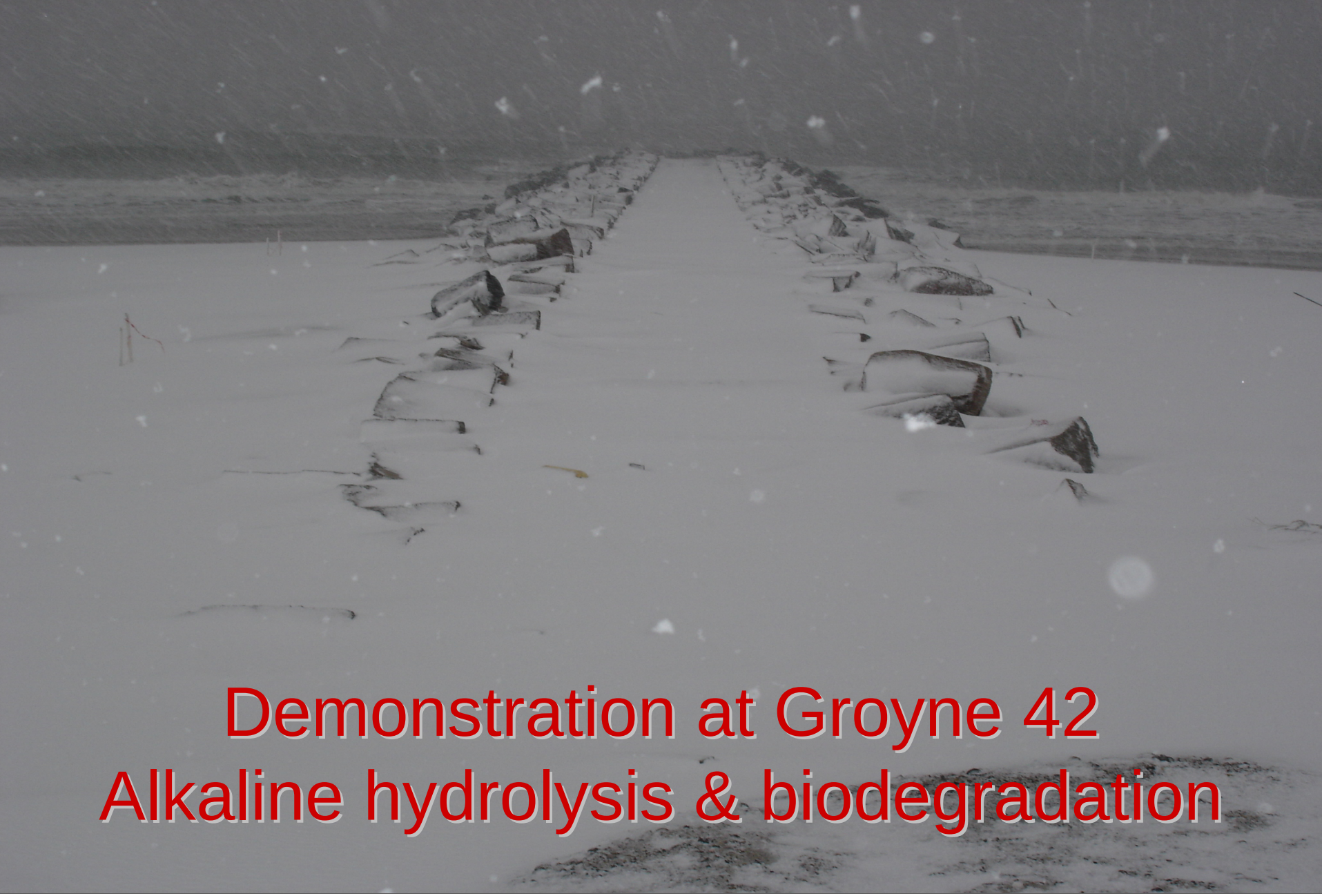

Demonstration at Groyne 42
Alkaline hydrolysis & biodegradation

watertech

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Outline

1) Introduction

2) Central Issues

3) Results

4) Plans

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1) Introduction

Why clean up?

1. to eliminate the smell on the beach (tourism)
2. to return the area to pristine conditions (wishful thinking)
3. to reduce contamination to same level as outside the sheet piling (mass reduction)
4. to achieve no-effect level for a target organism (risk reduction)
5. continue clean-up as long as it “pays” to do so (cost/benefit)
6. to ensure there is no future need for clean-up (political)
7. to stay out of the mass media’s interest sphere (political)
8. to be able to remove the “no bathing” sign (tourism)

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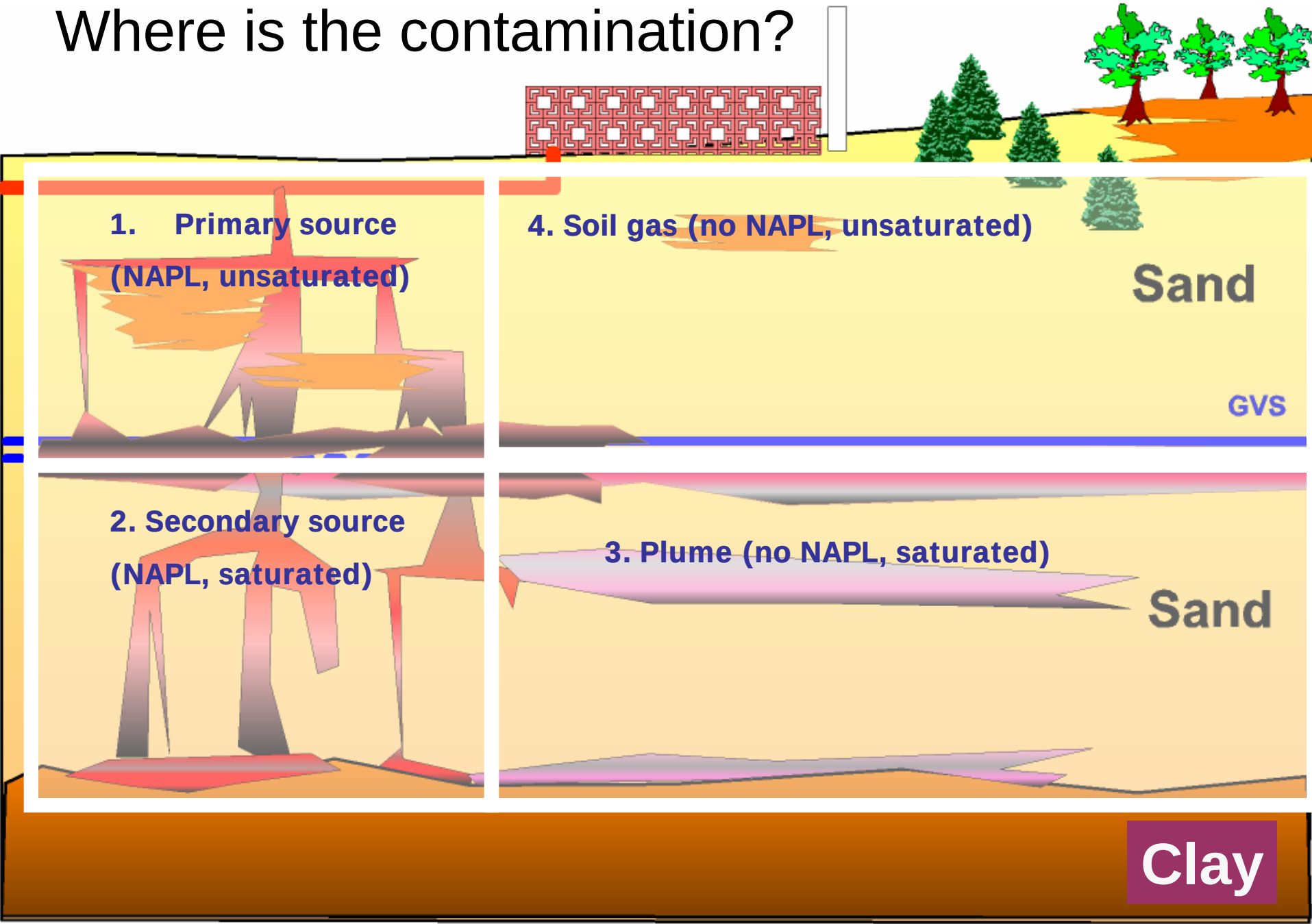
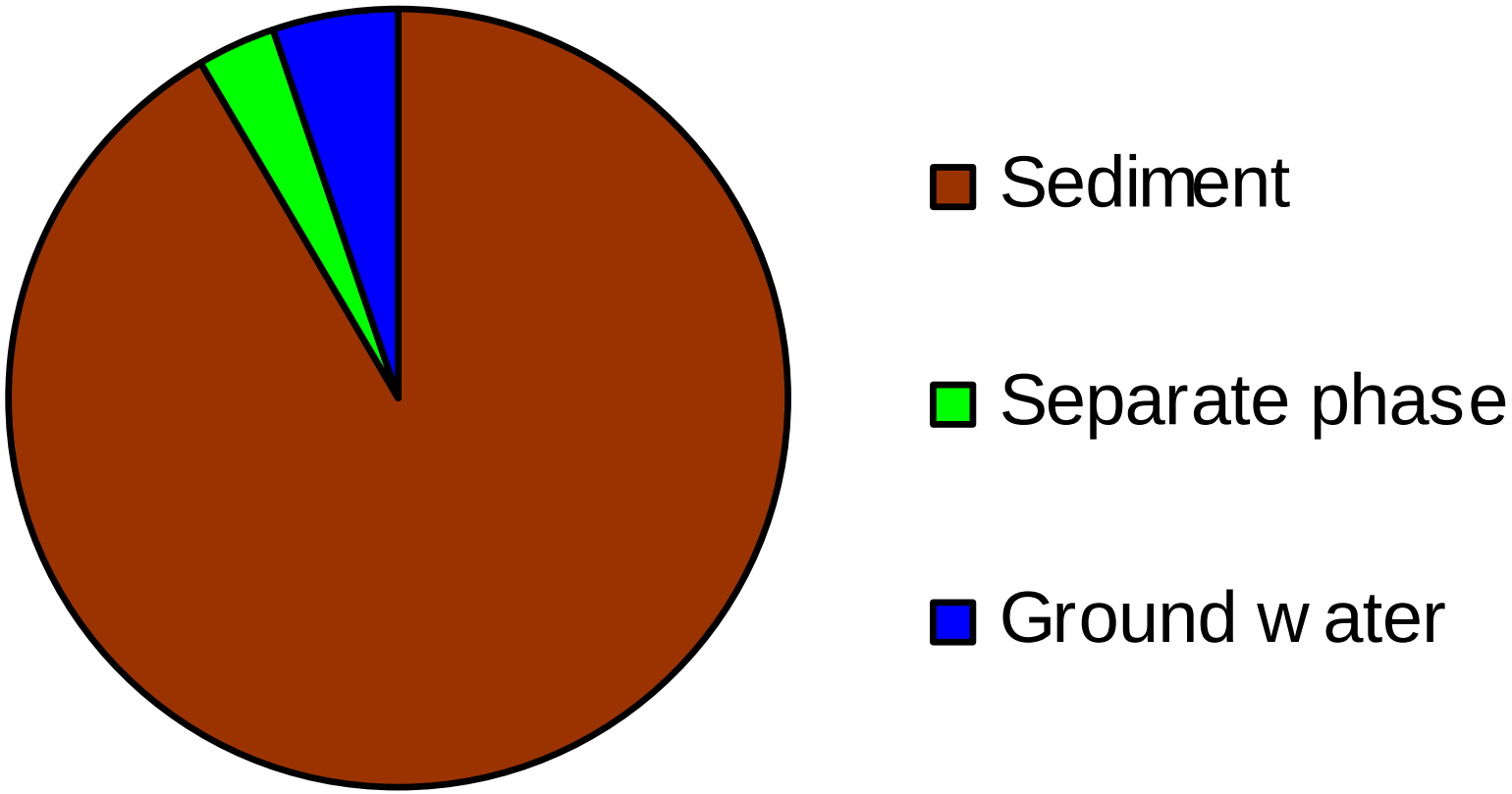
Where is the contamination?



Distribution of contamination



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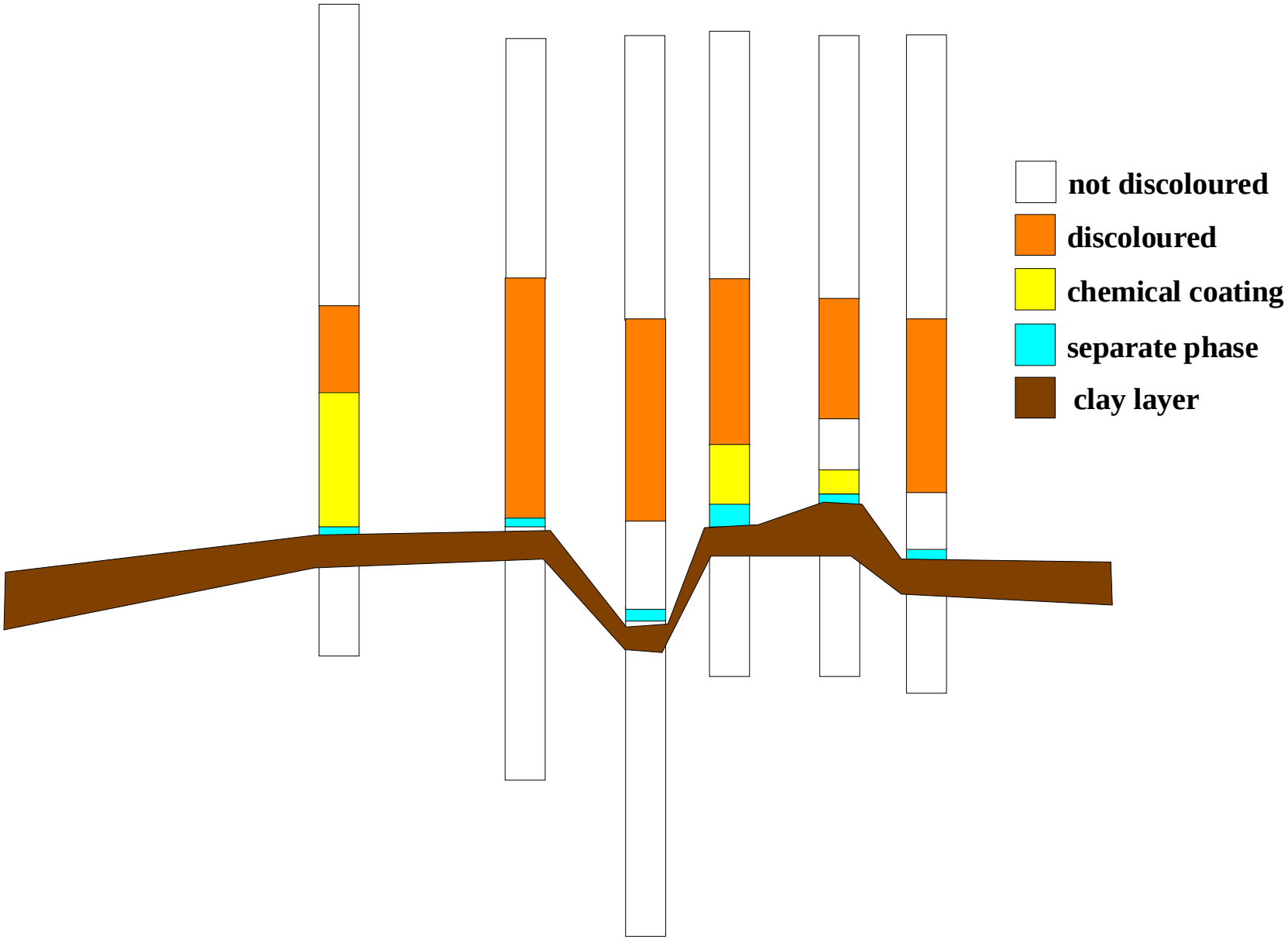
not discoloured
discoloured
chemical coating
separate phase
clay layer

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What is the contamination?

Parameter	Sediment (tons)	Separate phase (tons)	Ground water (tons)	Total (tons)
Parathion	**160**	6	0.04	170
Methylparathion	**53**	1.7	0.07	55
Malathion	18	0.2	0.05	18
Ethylsulfotep	6.3	0.3	0.03	6.7
Aminoparathion	3.5	0.1	0.2	3.8
EP2-acid	not calc.	not calc.	13	13
EP1	not calc.	not calc.	0.8	0.8
Mercury	1.7	0.1	0.02	1.8

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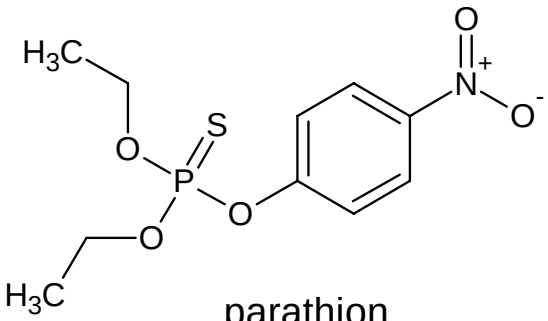
The selected treatment train

1. alkaline hydrolysis (aggressive, intensive)

2. biological degradation (long-term effect, extensive)

How does alkaline hydrolysis work?

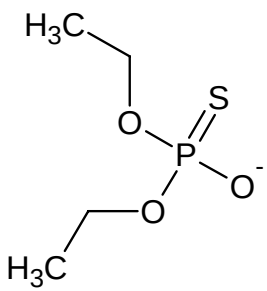


parathion
(EP-3)

+

HO^-

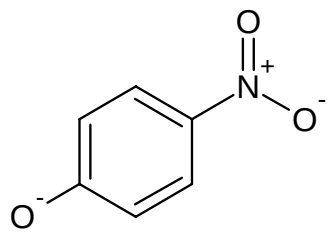
hydroxide



diester phosphoric acid

(EP-2 syre)

+



p-nitrophenol
(PNF)

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What is caustic soda?

- Also known as sodium hydroxide, NaOH
- Typically found in 27 % solution
- Inexpensive – 1 DKK pr. kilogram
- Can be transported by ship and in tank trucks

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Does biodegradation work?

1. contaminants and hydrolysis products very degradable
2. extensive method – just add oxygen!
3. plenty of N & P nutrients!

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Why not biodegradation alone?

1. high concentrations of contaminants are toxic to microorganisms
2. degradation produces strong acid – this stops biodegradation
3. strongly reduced - obtaining contact with oxygen practically impossible

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Strategy

1. abstract groundwater (treat water before discharge)
2. infiltrate sodium hydroxide
3. wait for alkaline hydrolysis to take place
4. repeat abstract and infiltrate sequence
5. neutralize aquifer
6. aerate soil gas and groundwater
7. allow biodegradation to take place

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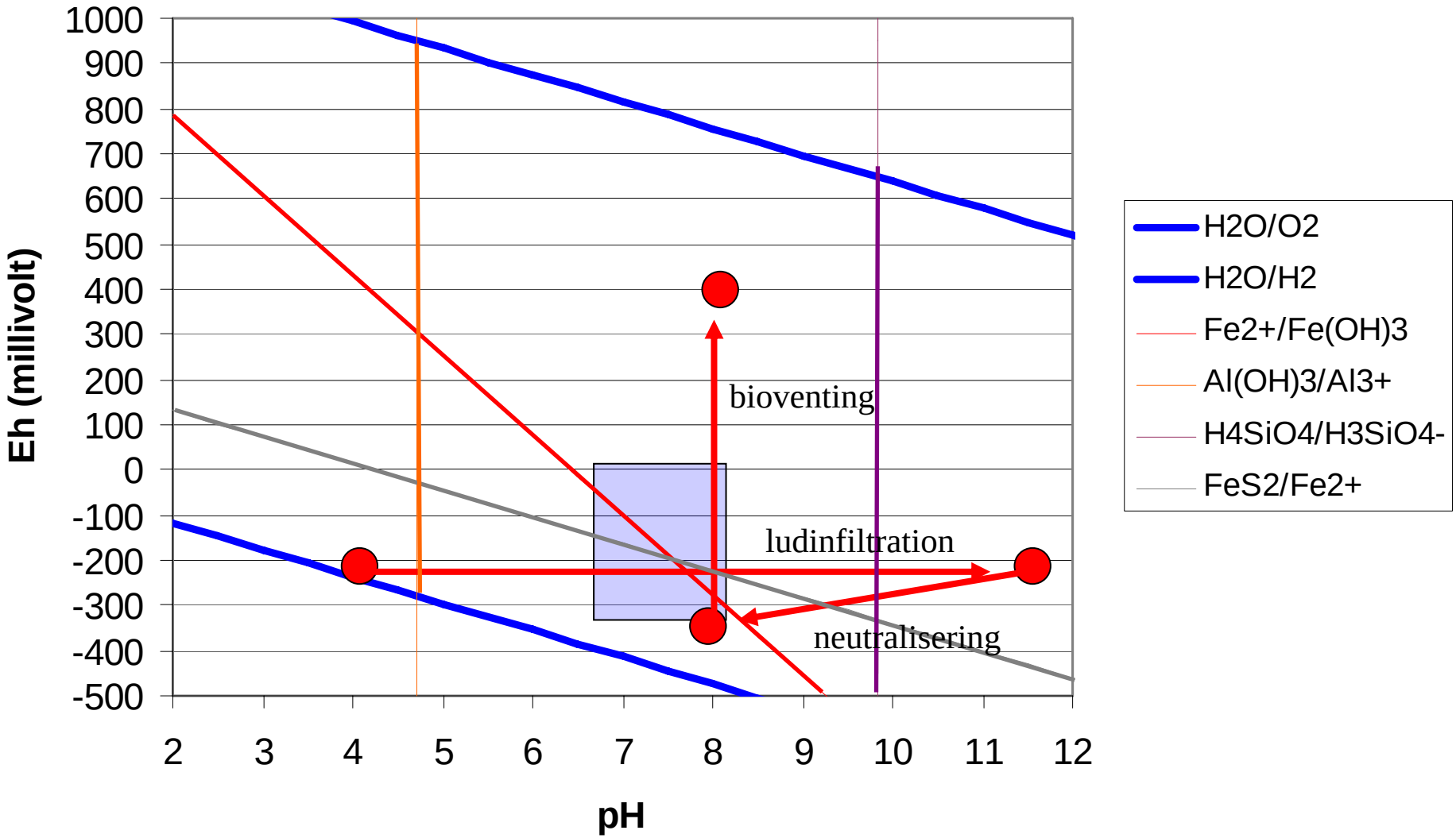
1000
900
800
700
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
Eh (millivolt)
2
3
4
5
6
7
8
9
10
11
12
pH
bioventing
ludinfiltration
neutralisering
H2O/O2
H2O/H2
Fe2+/Fe(OH)3
Al(OH)3/Al3+
H4SiO4/H3SiO4-
FeS2/Fe2+

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2) Central Issues

- Advantages

  Challenges/questions

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Advantages of alkaline hydrolysis

1. caustic soda is cheap
2. hydrolysis reaction is fast and not dependent on living organisms
3. sheet piling – water table is simply lowered, giving no tailing like in normal pump-and-treat
4. large pH-gradient is obtained
5. clogging problems reduced (no iron in infiltrated water, high pH prevents dissolving more iron, high pH cleans bacterial growth

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Advantages of biodegradation

1. inexpensive
2. contaminants have been shown to be degradable

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Challenges/questions

Very large site area

Caustic soda must come in contact with the contamination just above the clay layer

Work environment – parathion & caustic soda

High pH kills microorganisms – they must be reintroduced

Clogging of wells – caused by iron or microorganisms?

How much contamination is below the clay layer?

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3) Results

1. Infiltration
2. Buffer capacity
3. Hydrolysis

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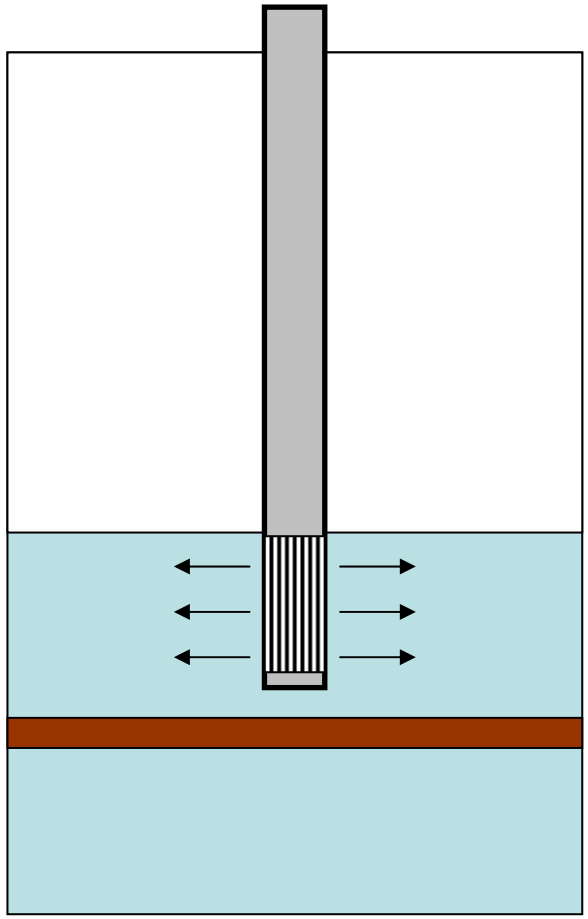
How many wells are needed to infiltration caustic soda?



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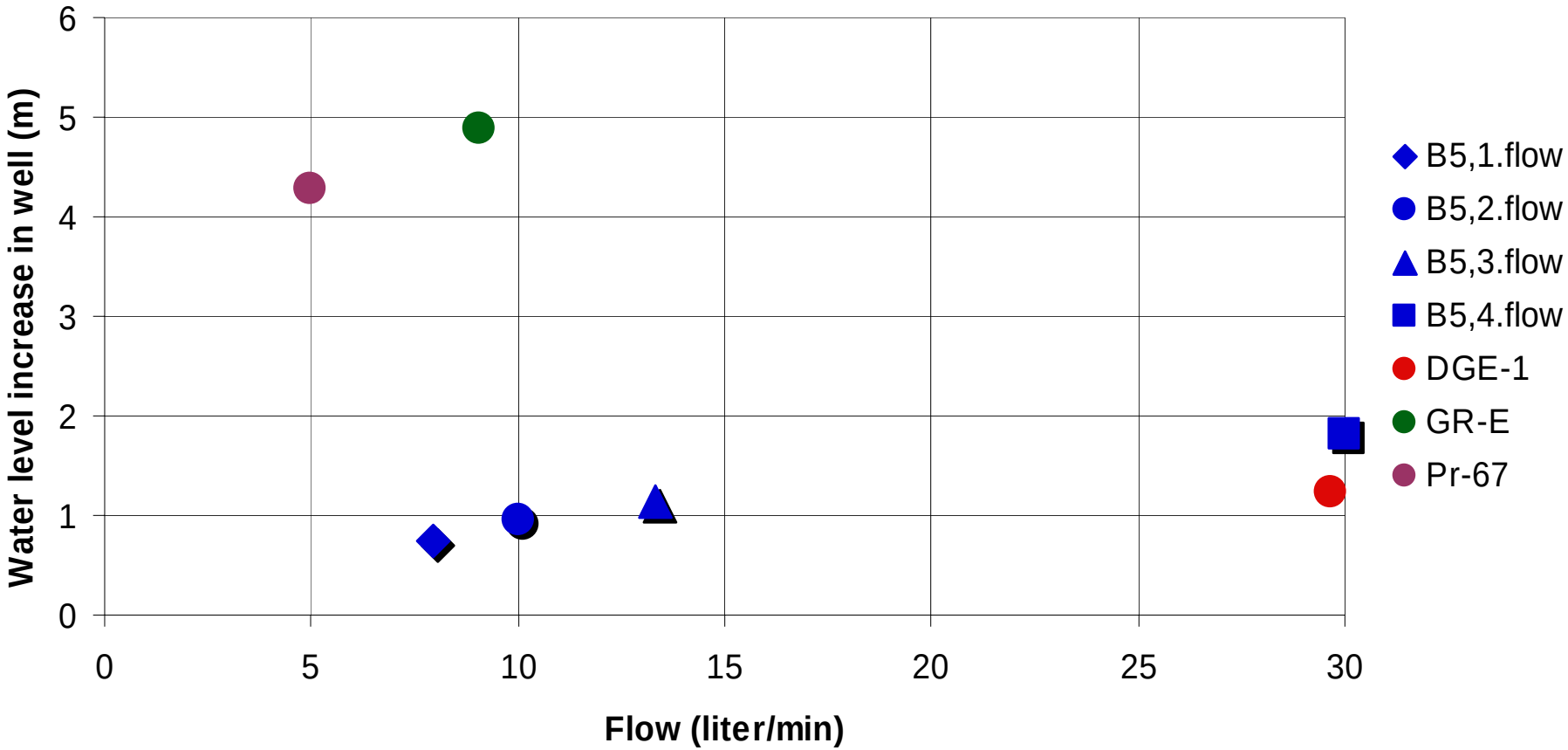
Infiltration tests



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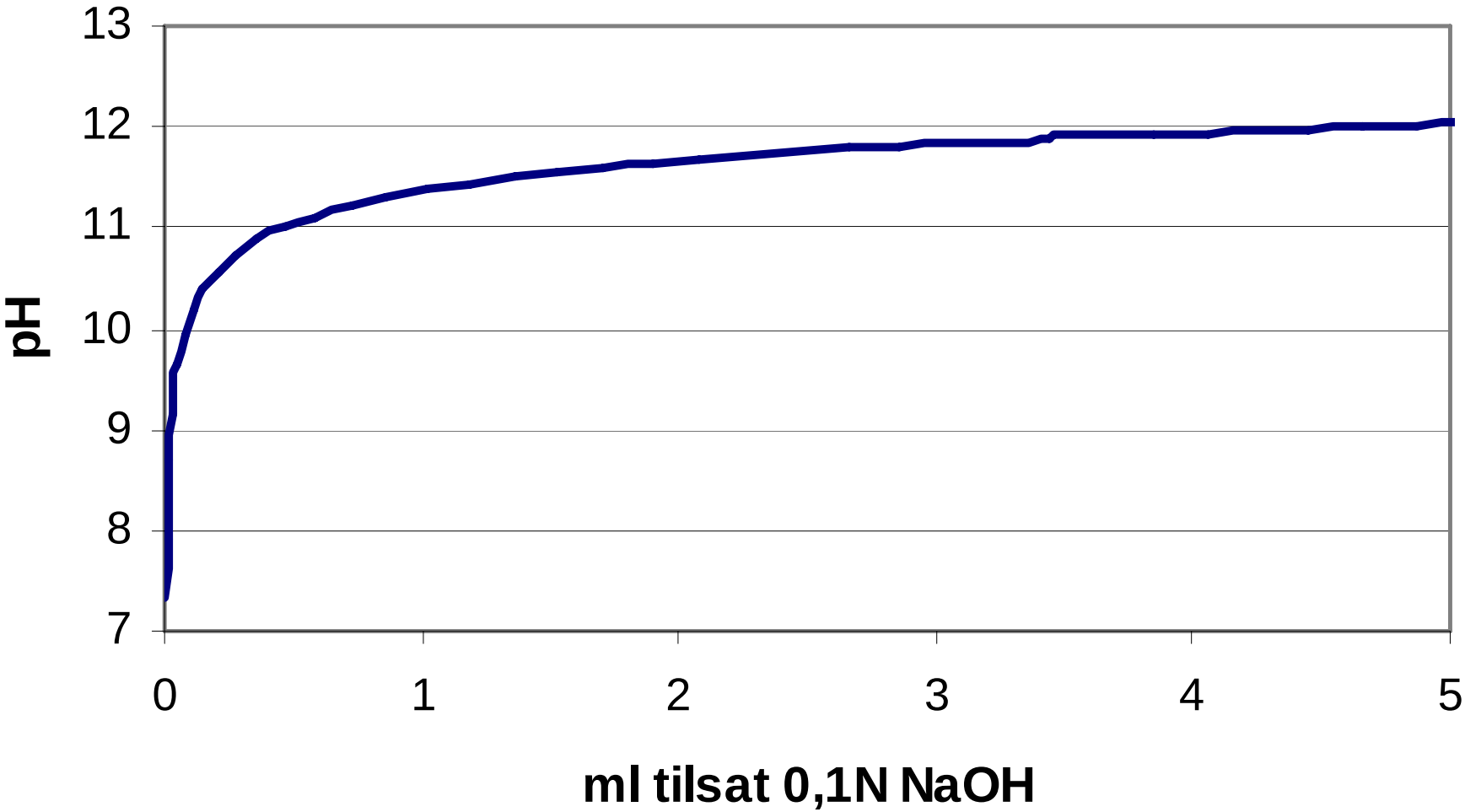
What is the buffer capacity of the sediment?



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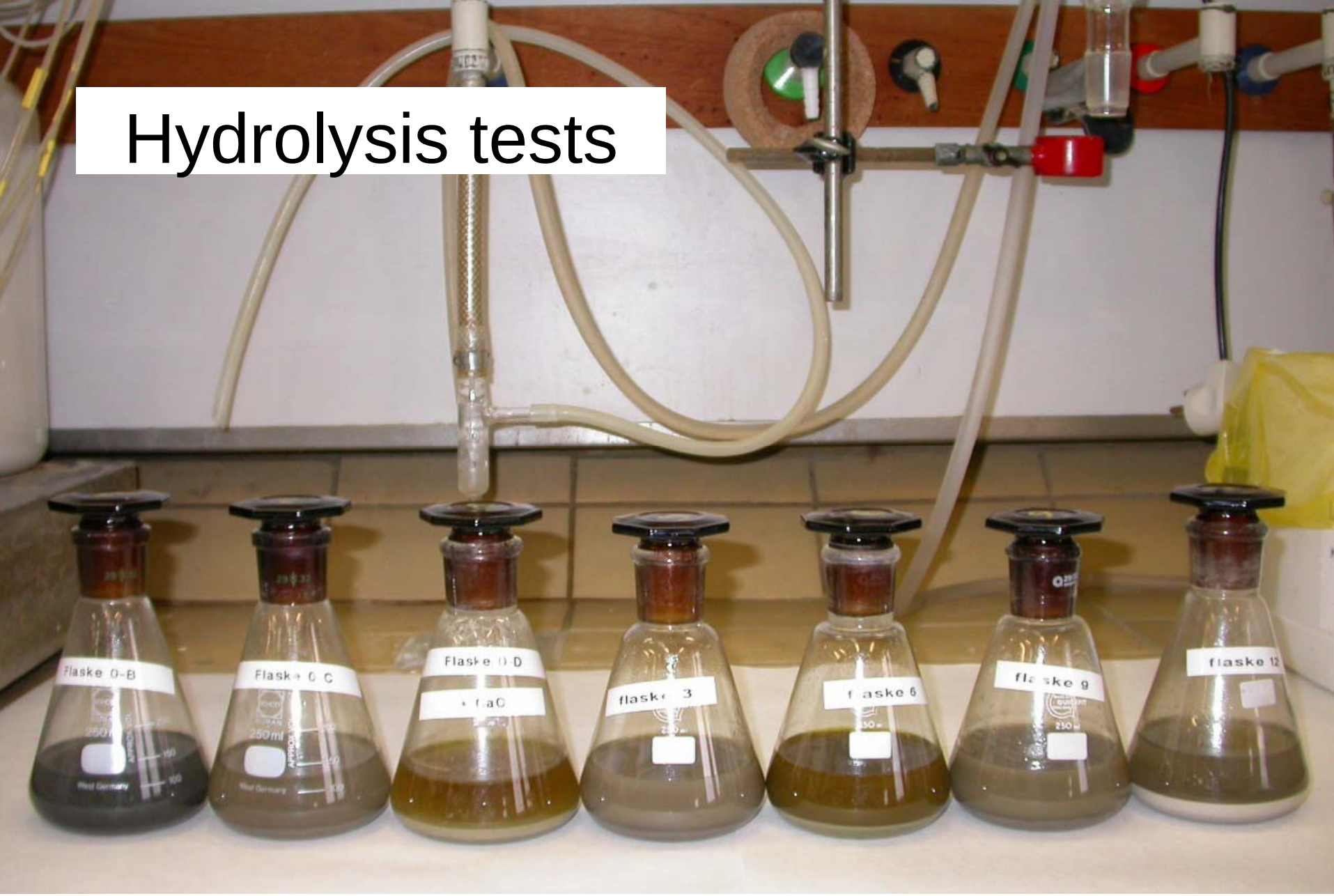
Hydrolysis tests



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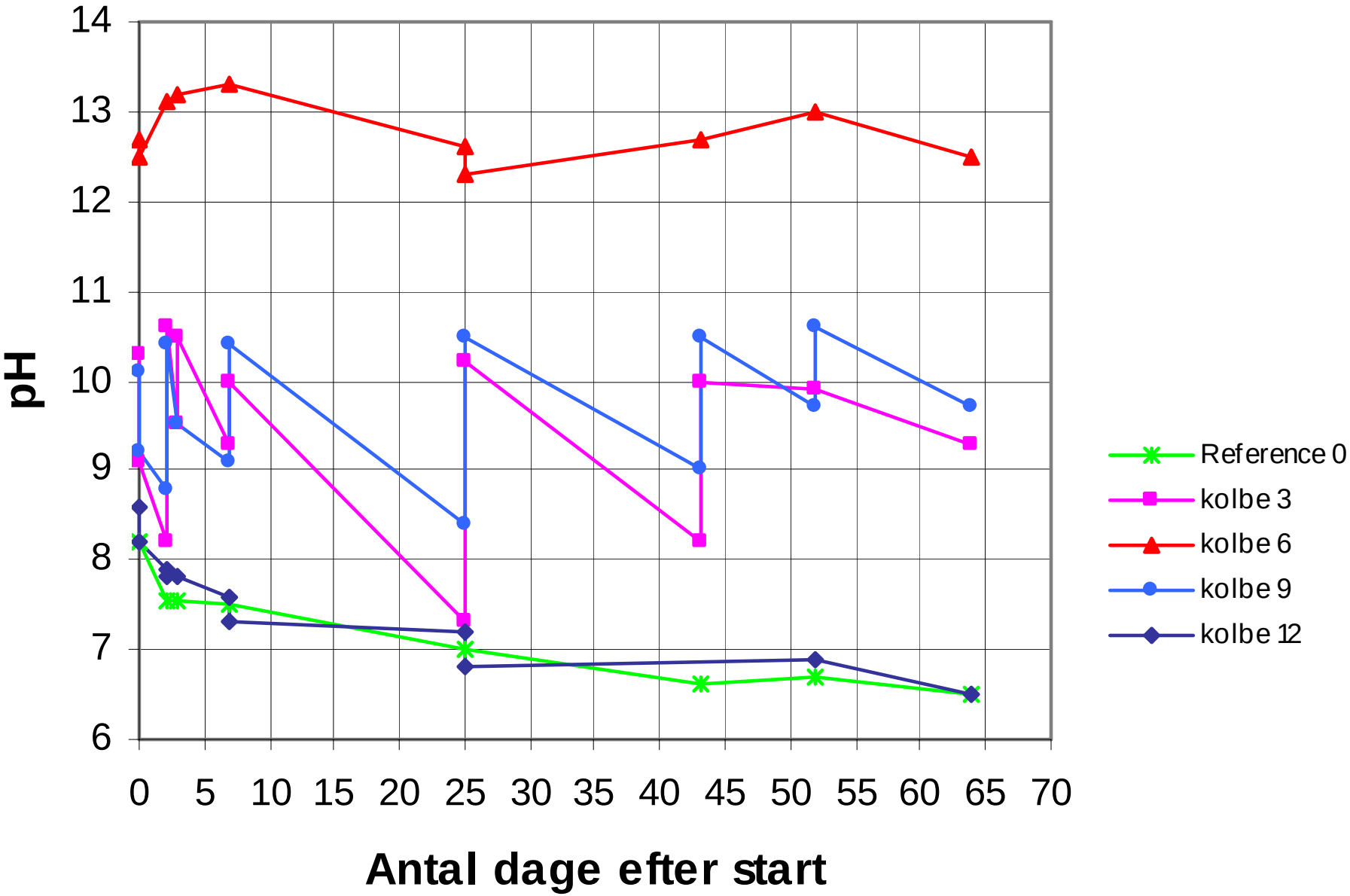
pH
14
13
12
11
10
9
8
7
6
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Antal dage efter start
Reference 0
kolbe 3
kolbe 6
kolbe 9
kolbe 12

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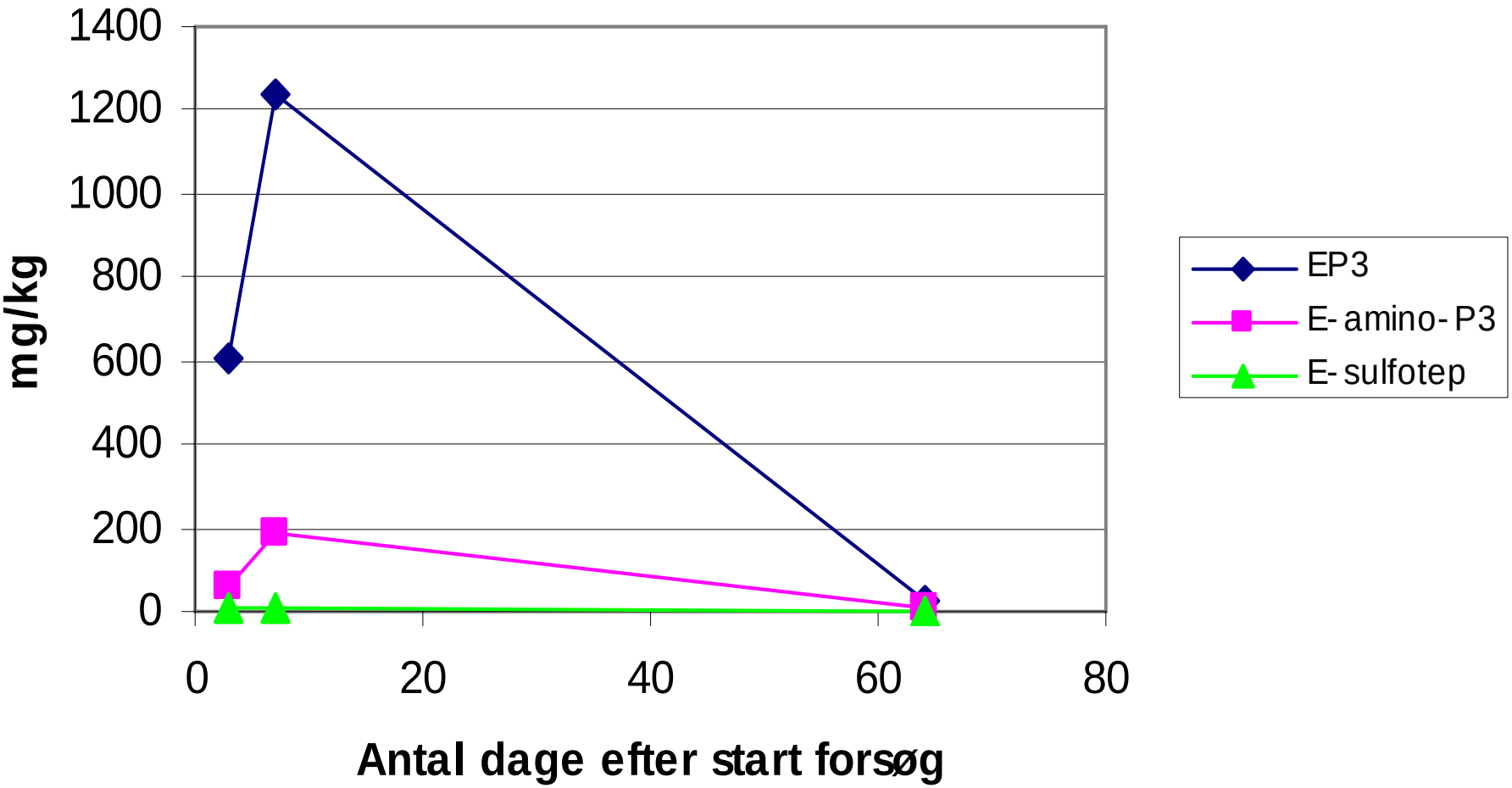
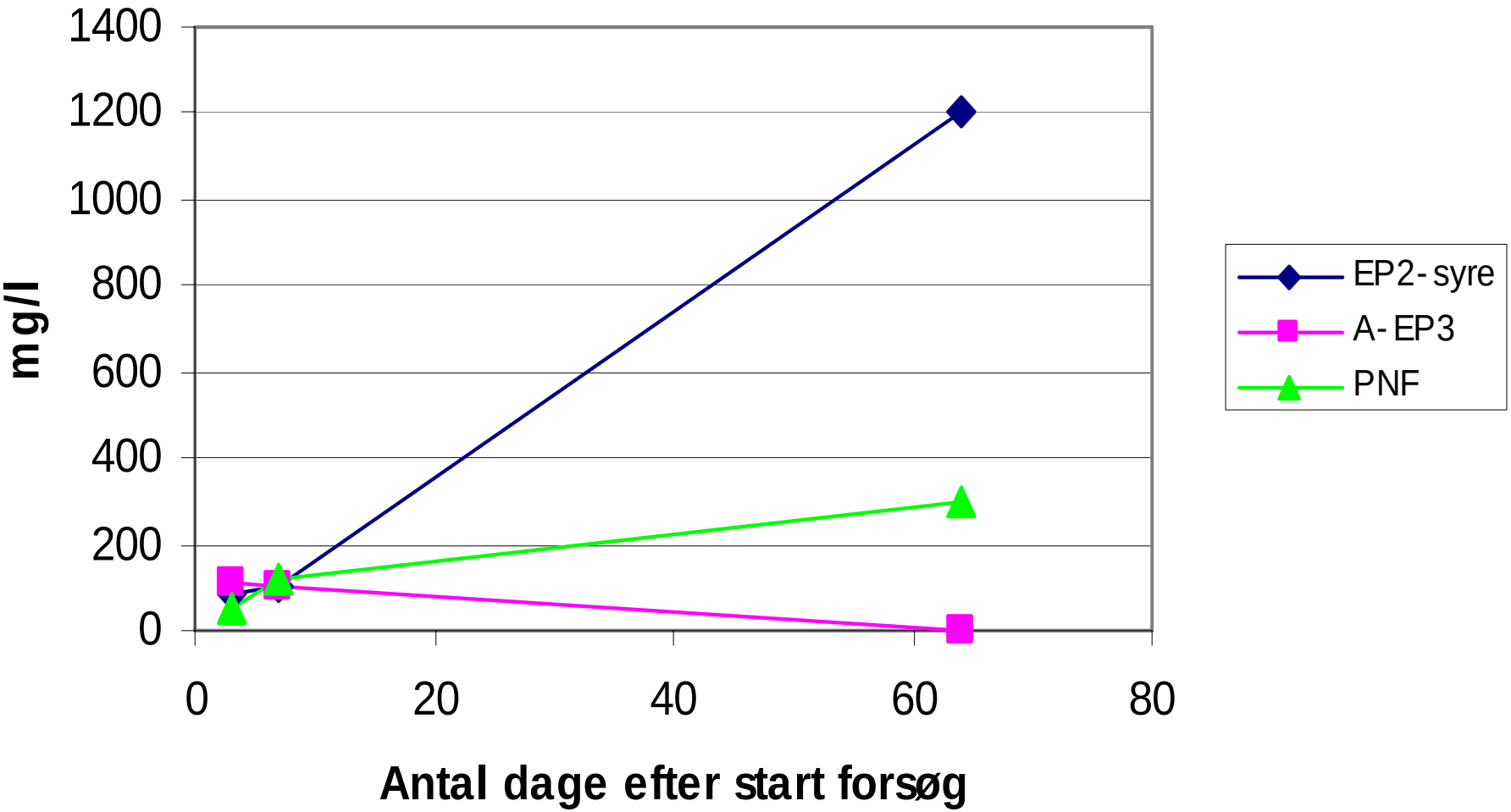
Indhold af færdigvarer, pH 13, sandprøver



Hydrolyse-rester, pH 13, vandfase



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4) Plans

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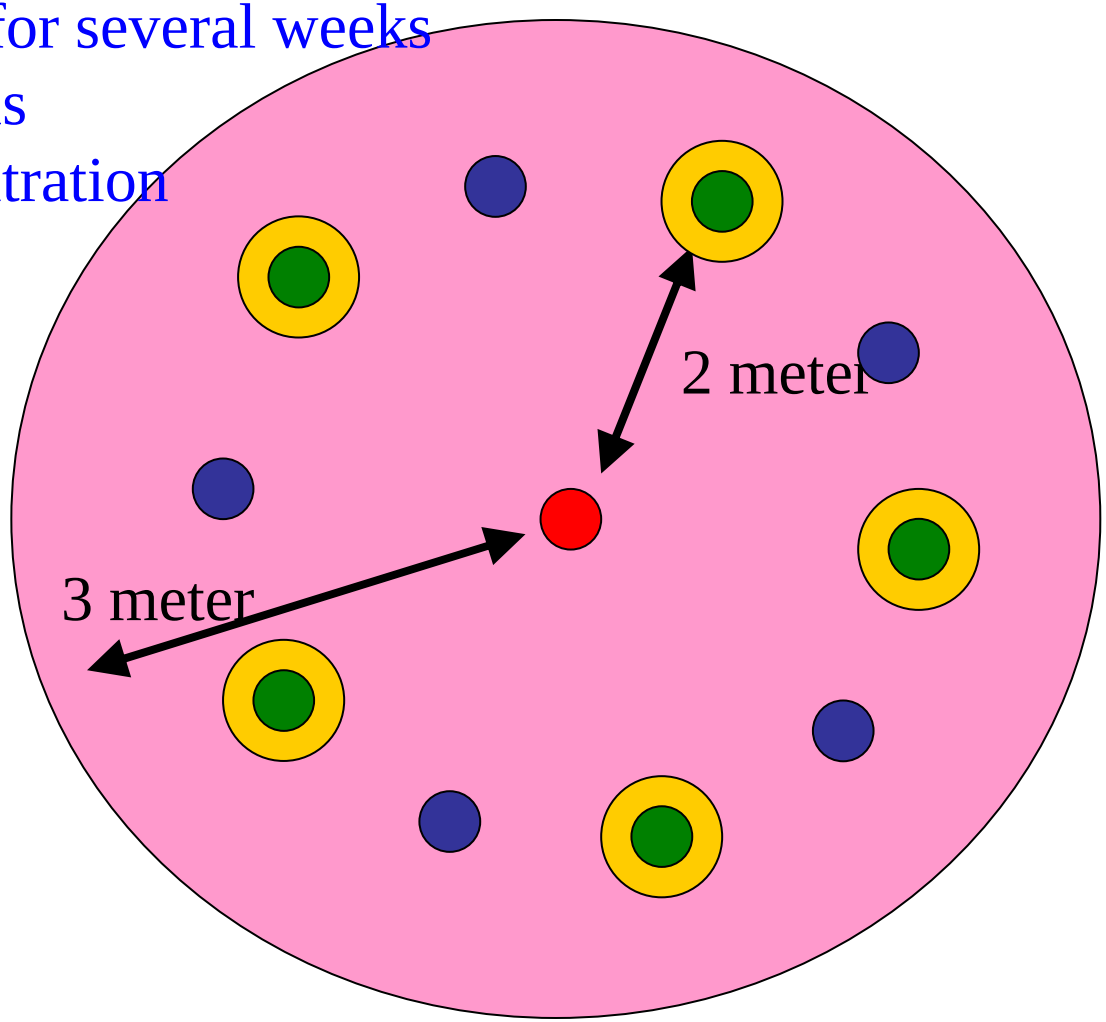
Pilot scale infiltration

1. Monitering well
2. Infiltration of caustic soda
3. Monitering for several weeks
4. Control wells
5. Ethanol infiltration



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AB HANNELLS INDUSTRIER
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