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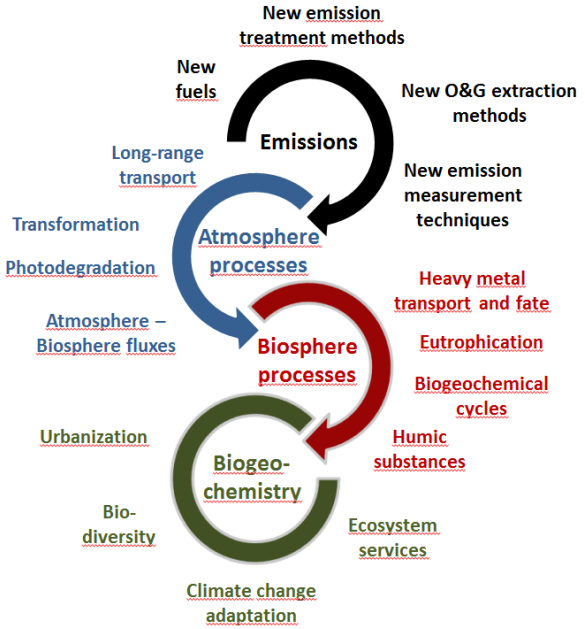
Health, Safety and Environment (HSE)

KJM3070 Colloquium



Safe Job Analysis (SJA)

- Safe job analysis
  must be made for all
  analytical operations
  representing any danger

  – What can go **wrong**?
  – What can we do to **avoid** this?
  – What can we do to **minimize** the damage?

Risk assessment: CertoClav 12L Autoclave

What can go wrong	Possible Risk	What can be done to prevent accidents	What can be done to reduce the consequences if an accident should occur
Explosion due to very high pressure inside chamber (above 4,1 bars)*	Burns, blindness, and possible risk of death	Work in the hood Wait enough time at the end of the experiment, so that the pressure has fallen to 0 bars and the temperature is below 80°C. Use gloves to take out the samples. Follow carefully the step by step procedure for operating the autoclave (instructions given on autoclave) Always consult an experienced user of the instrument for a demonstration before running the instrument for the first time.	Leave the area if accident should occur & contact safety inspector Vidar Blekestad, supervisor Rolf Vogt, Alexander Engebretsen or Christian W. Mohr. Place the burned area under cold water. If serious accident should occur contact ambulance and medical help (telephone no.: 113)
Severe burns due to high temperatures (≈121°C)	Burns		

*The autoclave is setup with safety vents in order to avoid explosions. However the instrument must always be treated with the possibility of safety failure.

Safety rutines

- HMS0504 – Feltsikkerhet
  should have been taken before the fieldwork ;-)
- HMS0503 – Laboratoriesikkerhet
  must be taken before the lab work

- In the lab you must use **goggles**
- The doors to chemicals must be **locked**
  - Door to lab must be **locked**
  - Cabinets must be **locked** and key hidden

Health Safety and Environment

- All participants need to fill in field card form for participants
  - https://nettskjema.no/a/130224#/page/1
    - **Responsible of the field: Rolf D. Vogt**
    - **Project name or course number: KJM3070**
    - **Start/ Starting date of the field work: 23.10.2020**
    - **Finishing date of the field work: 23.10.2020**
- Participation is mandatory
  – though send me an e-mail and explain why if it is impossible within 2 days

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Analysis plan

Colloquium, KJM3070

Lab work

Conductivity

- Conductivity meter
  - The instrument is calibrated using
    84 µS/cm calibration solutions
- The measurements are done for **quality control** purposes in order to compare measured and calculated conductivity
- Determined as described in ISO7888 using non-filtered water sample and preferably measured at 25°C.
- The reading is presented as mS m^{-1} (1mS m^{-1} = 10µS/cm)
- No SJA needed

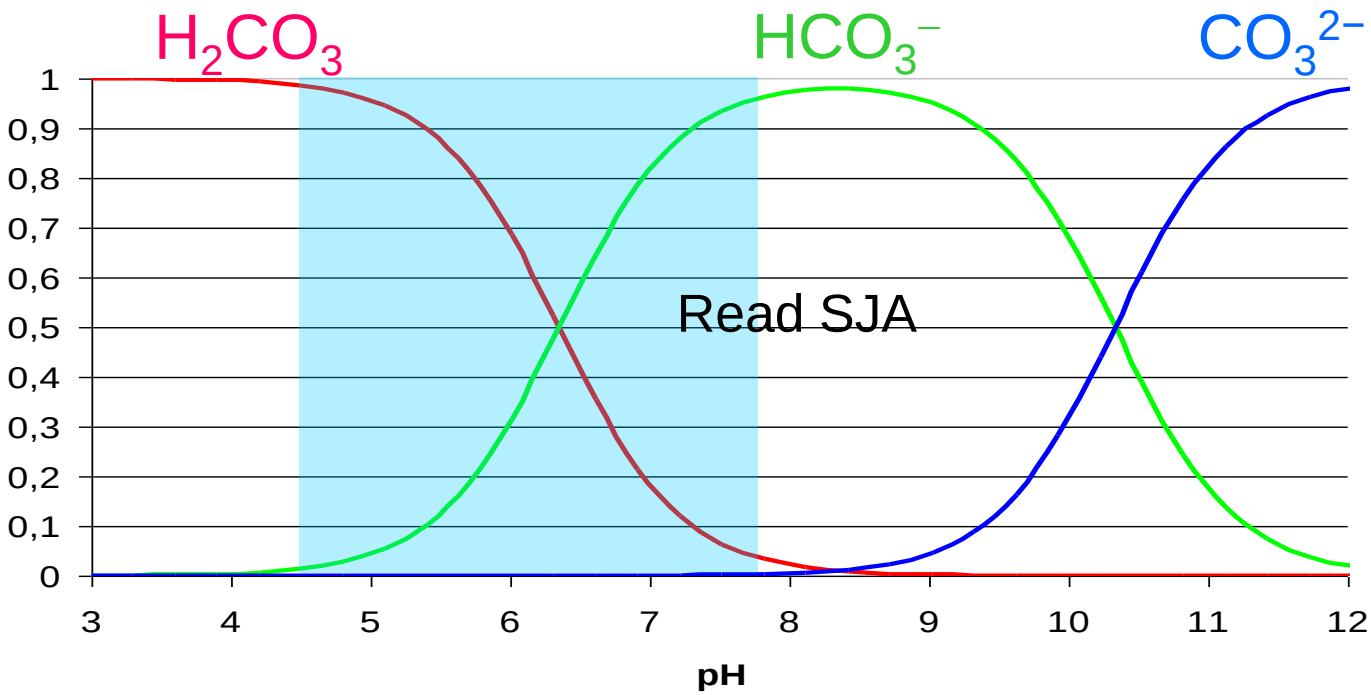
{H^+} determined using pH electrode

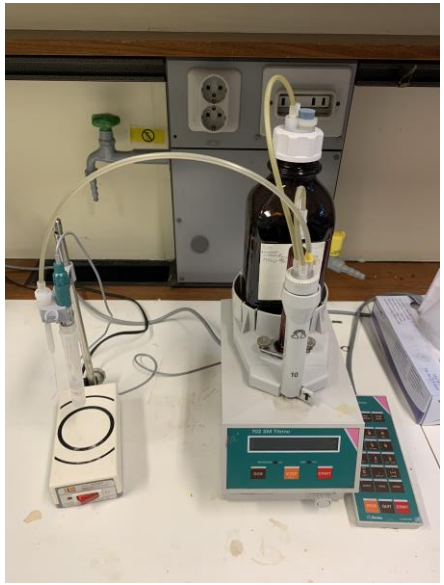
- Orion pH-meter
  with a Ross pH electrode
  - The pH-meter is calibrated with
    pH = 4.00 and 7.01 buffer solutions
- Risk of degassing of CO_2
  - Stir till stable – wait till stable
- Determined as described in ISO10523
  using non-filtered water sample
- Measurements should preferably
  be conducted at 25°C
- No SJA needed

Total Alkalinity titration

- Determined potentiometrically as described in ISO9963
- Titration with acid to pH 4,5 and preferably measured at 25°C

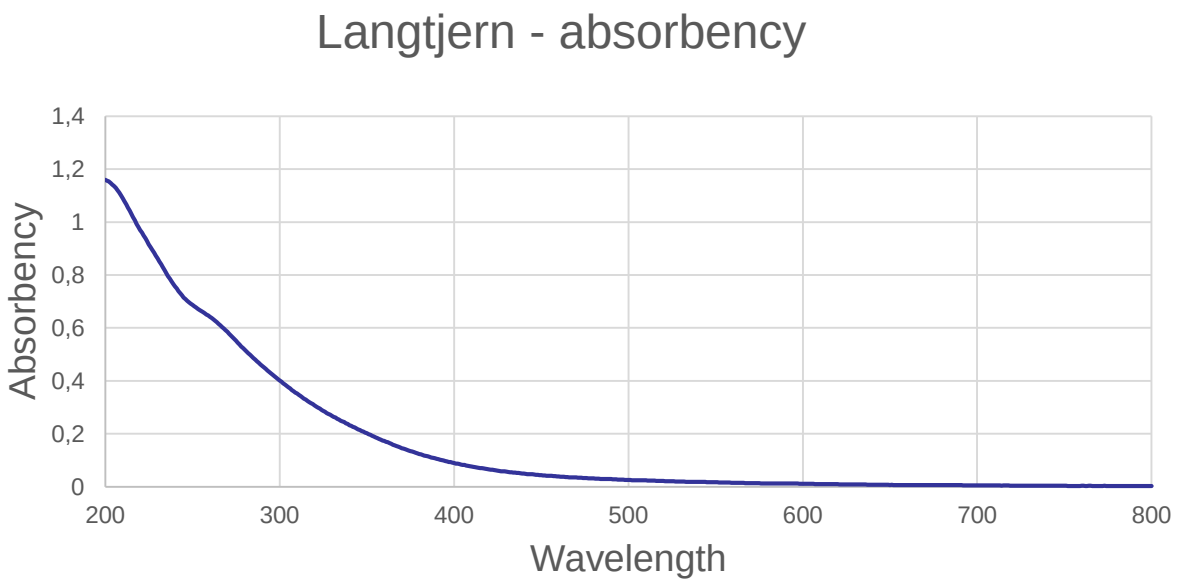
  $CO_3^{2-} + HCO_3^- + 3H_3O^+ \leftrightarrows 2H_2CO_3 + 3H_2O$
- Total alkalinity (=$[HCO_3^-]+2[CO_3^{2-}]$) + H^+ needed to change the pH from sample pH down to pH 4.5 Endpoint in the acid range
- ➔ Also other weak acids (A^-, $Al(OH)_n^{3-n}$)



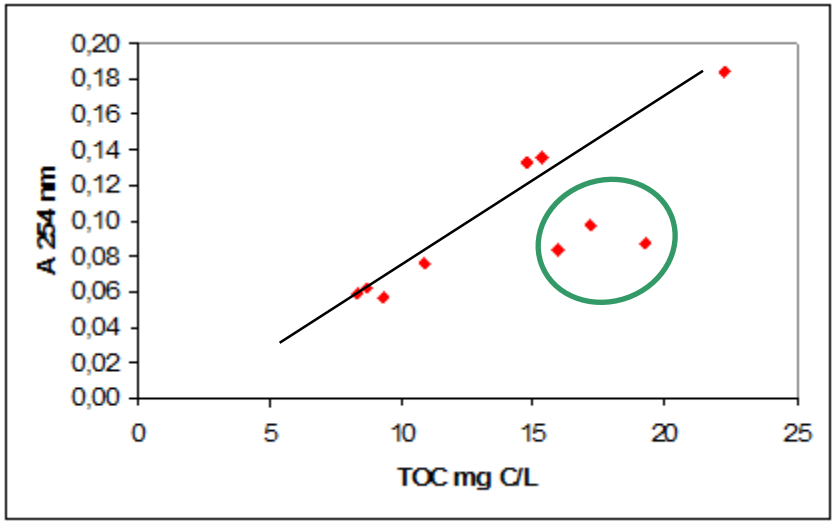


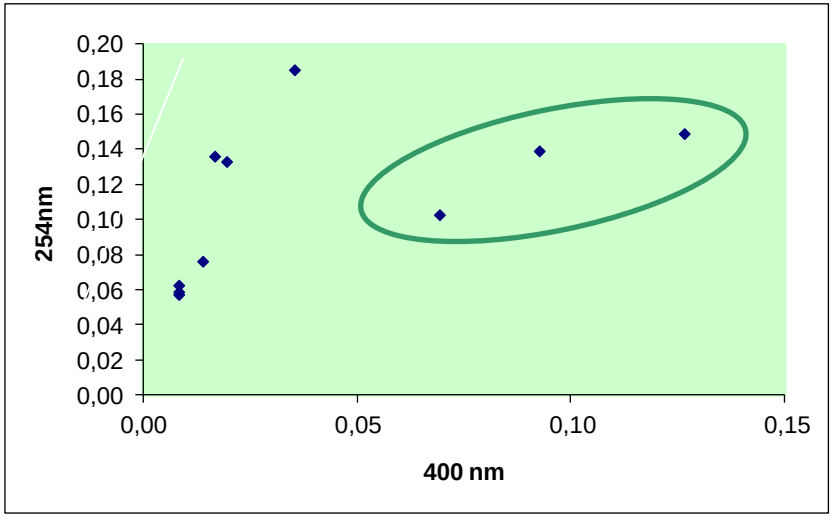
UV-vis

- Measurement of absorbency scan and @ λ254, 400 and 600nm
- Absorbency at UV 254 nm is commonly used as a proxy for Dissolved Natural Organic Matter (DNOM)
  - Strongly correlated with TOC due to conjugated double bonds chromophores



- Measurement of absorbency scan and @ λ254, 400 and 600nm
- Absorbency at UV 254 nm is commonly used as a proxy for Dissolved Natural Organic Matter (DNOM)
  - Strongly correlated with TOC due to conjugated double bonds chromophores
- Algae absorb light at UV 254 nm, but more than DNOM at VIS 400 nm
- Read SJA

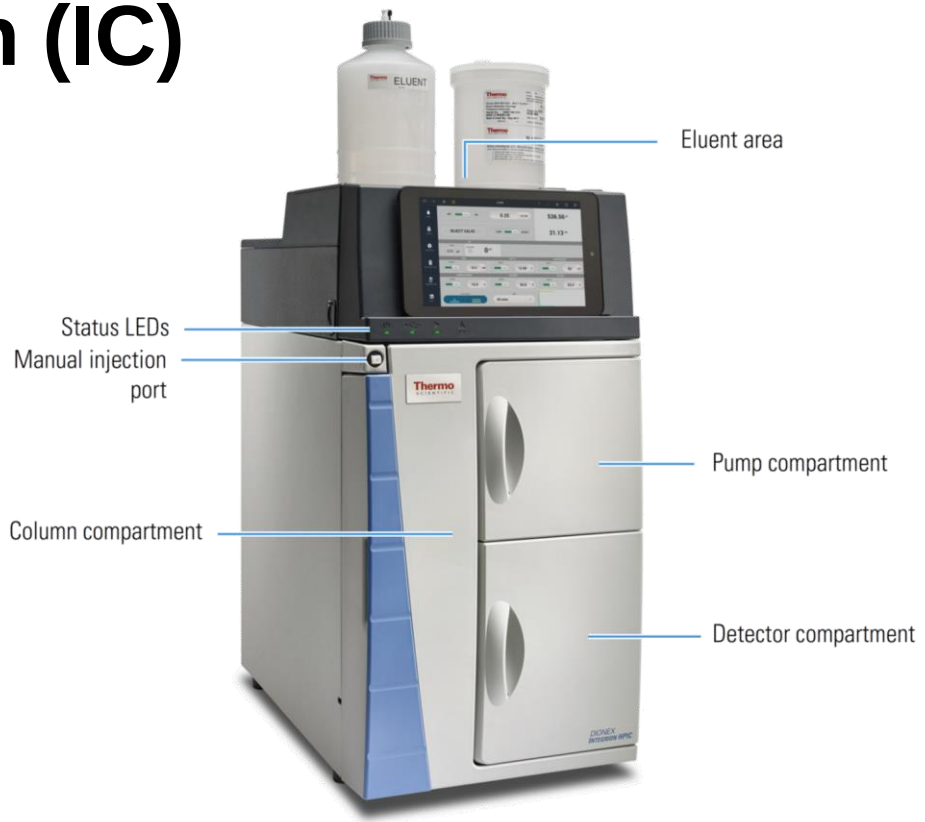


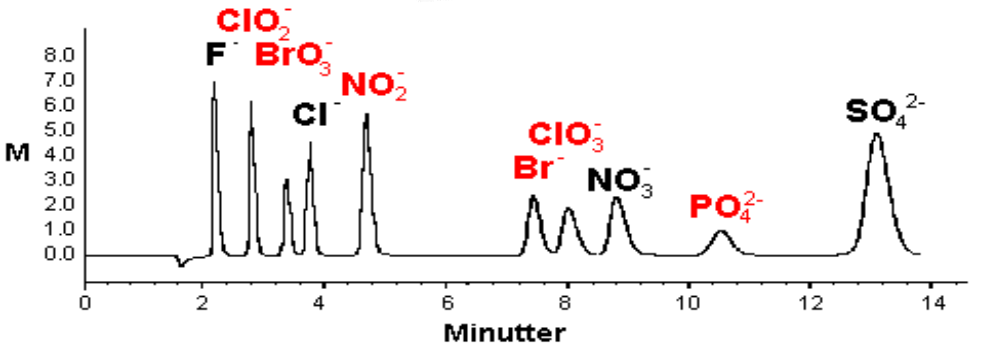


Analytical Instrument analysis

Major anions to be determined by Ion Chromatograph (IC)

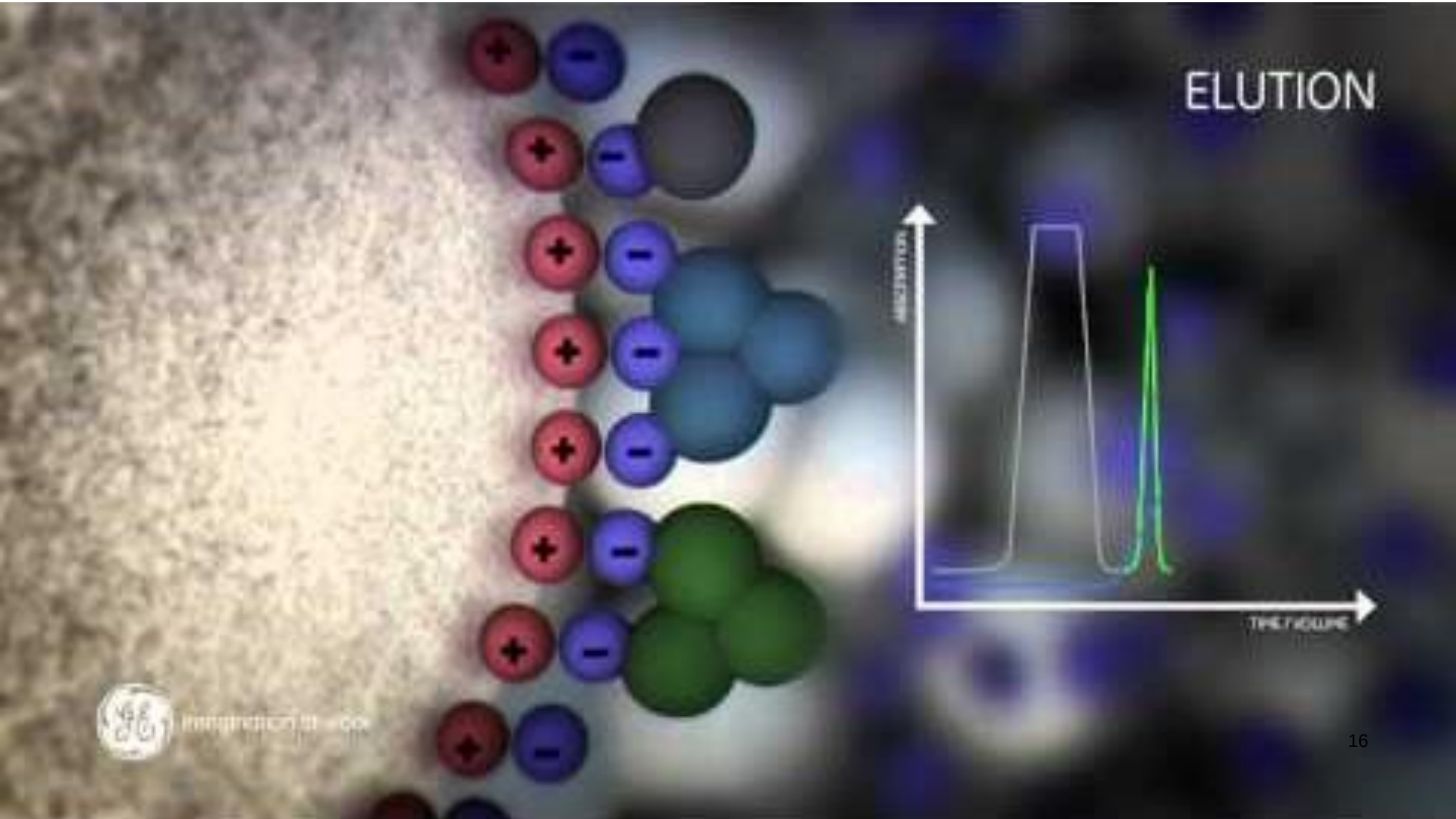
- Principle
  - The sample is injected in a flow of eluent
  - The analyte ions are separated by different degree of binding to the active sites on the ion exchange material
  - Cations are exchanged with H^+
  - The activity x specific conductivity of the analyte along with H^+ in the eluent stream are measured by means of a conductometer





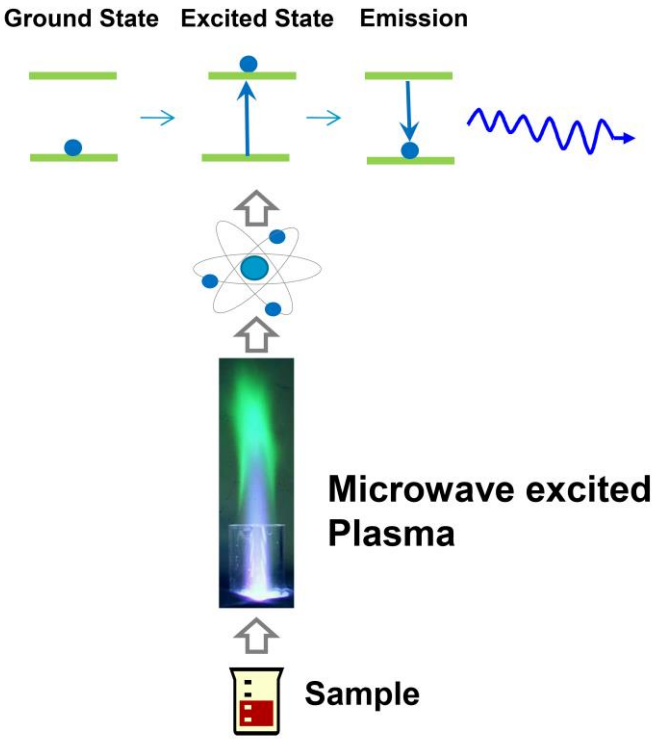
Major anions to be determined by Ion Chromatograph (IC)

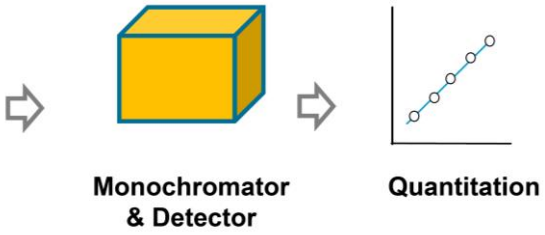
https://www.youtube.com/watch?v=q3fMqgT1do8

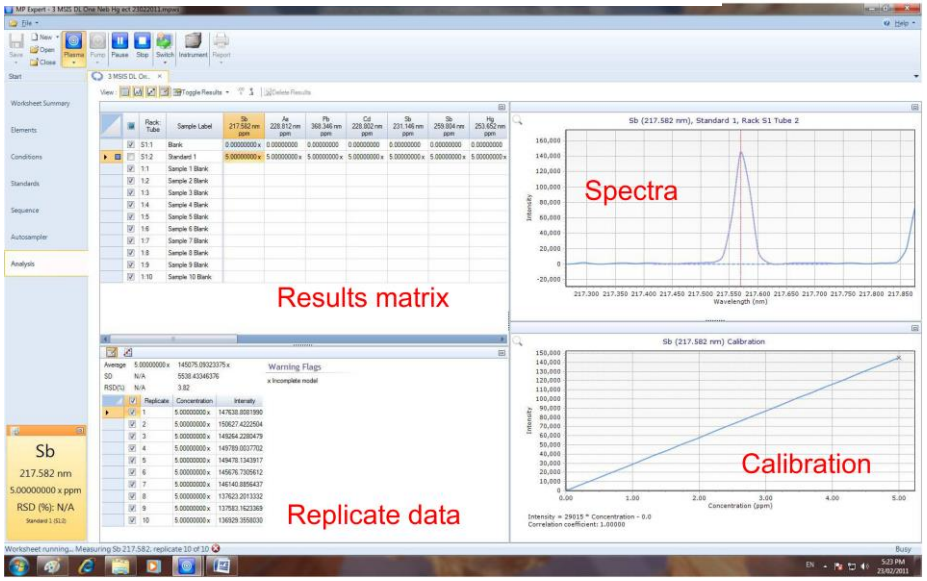


Major cations to be determined by MP AES

= Microwave Plasma – Atomic Emission Spectrometer







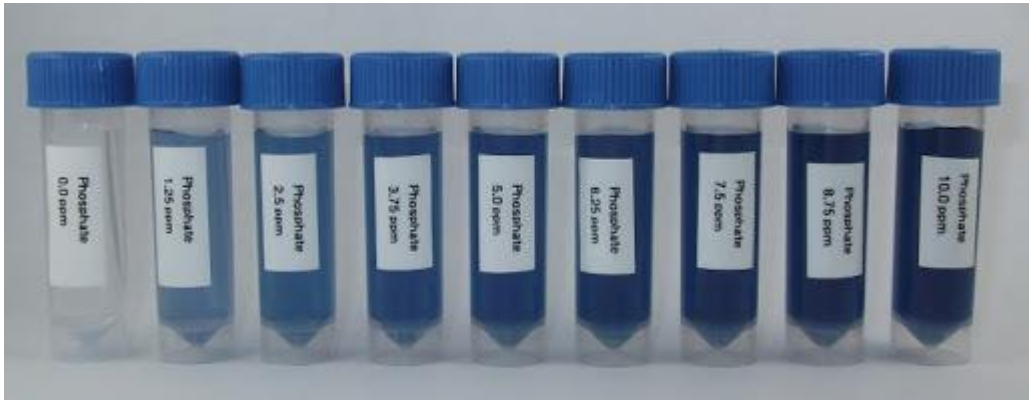
Major cations to be determined by MP-AES

https://www.youtube.com/watch?v=sRwpw614aPg, 0’59 to 3’22’’

External analysis

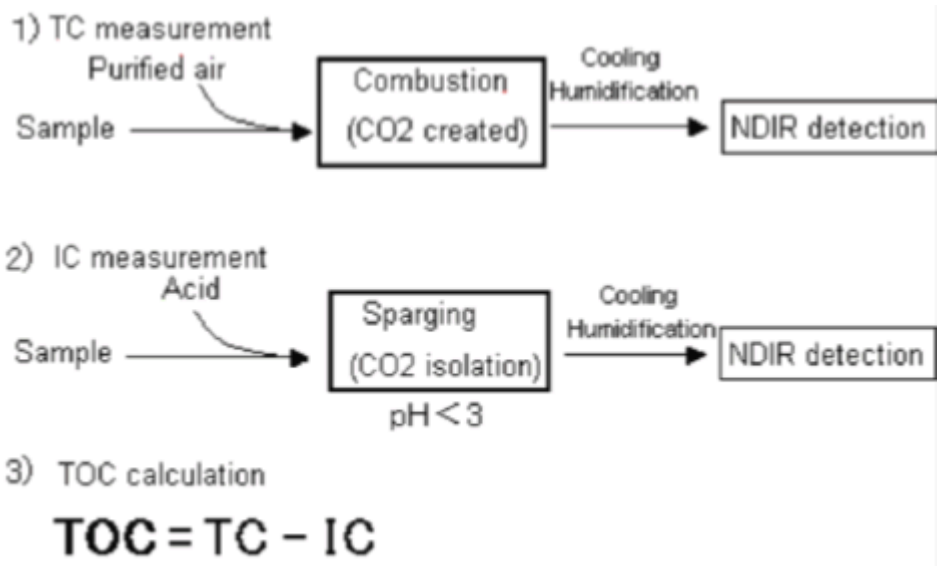
P determination

- Orthophosphate reacts with ammoniummolybdate to a yellow-coloured phosphorousmolybdate acid, that is reduced with ascorbic acid in the presence of antimony to a strongly blue coloured complex
- This colour is measured photometrically as described in Norwegian Standard (NS 4724)



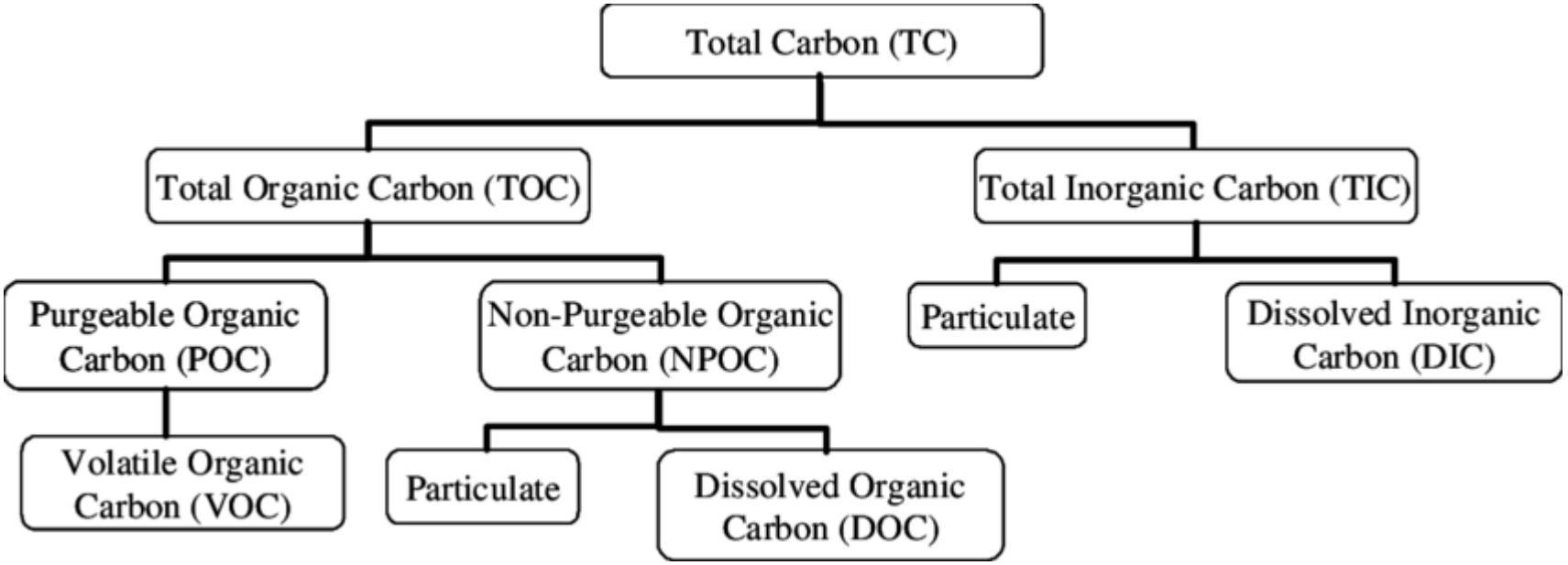
Total organic carbon

- High temperature (680ºC) catalytic combustion analysis on a Shimadzu TOC instrument
- Principle:
  - The organic carbon is combusted to **CO_2** by high temperature and catalysis. The amount of CO_2 produced is measured using an **IR detector**



Total organic carbon

- Analytes measured may include:



Total nitrogen

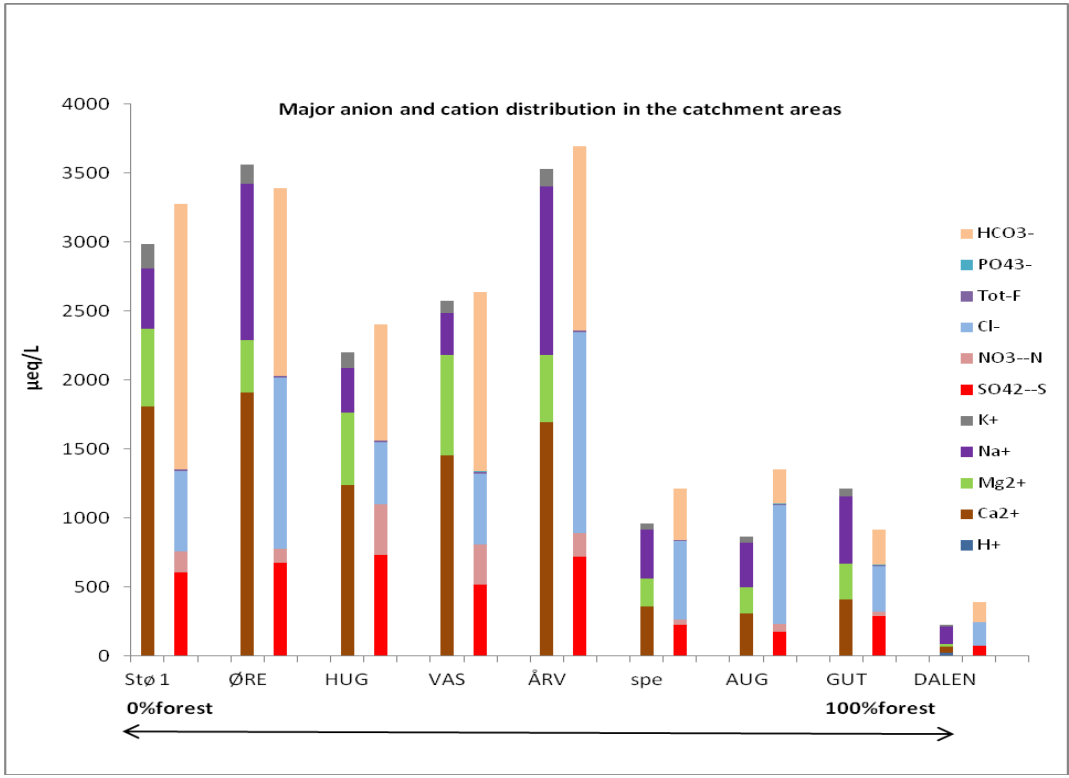
- Total Nitrogen couples the Shimadzu TOC with a chemiluminescent nitrogen detector.
- The combustion tube is packed with a catalyst (platinum on an alumna support) and assembled in a furnace and heated to 720° C.

Reaction 1	$4NH_3 + 5O_2 > 4NO + 6H_2O$
Reaction 2	$2(NH_2)_2CO + 5O_2 > 4NO + 4H_2O + CO_2$
Reaction 3	$NO + O_3 > NO_2 + O_2$
Reaction 4	$NO + O_3 > NO_2^* + O_2$
Reaction 5	$NO_2^* > NO_2 + h\nu$

Data assessment

Problems with analysis of major anions and cations in water

- Anions are analysed in filtered raw water
- Cations are analysed in filtered water digested in acid (HNO_3)
  - Colloidal material (<0.45µm) is included in the cation analysis but not in the anion analysis



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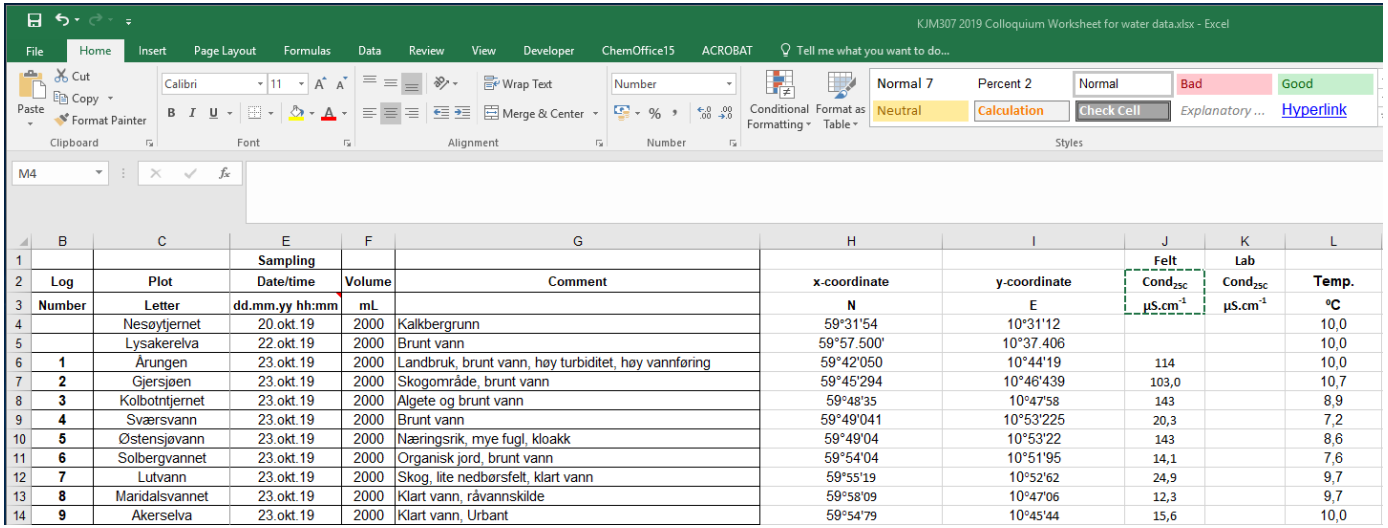
Species in natural freshwater

Central equilibriums in natural water samples

KJM3070

Compilation, calculations and QC of data

- After the analysis the data must be:
  - compiled
  - reckoned in terms of **equivalent charge** and
  - **quality controlled** by ion balance and agreement between measured and calculated conductivity



	B	C	E	F	G	H	I	J	K	L
1			Sampling					Felt	Lab	
2	Log	Plot	Date/time	Volume	Comment	x-coordinate	y-coordinate	$Cond_{25C}$	$Cond_{25C}$	Temp.
3	Number	Letter	dd.mm.yy hh:mm	mL		N	E	$\mu S.cm^{-1}$	$\mu S.cm^{-1}$	°C
4		Nesøytjernet	20.okt.19	2000	Kalkbergrunn	59°31'54	10°31'12			10,0
5		Lysakerelva	22.okt.19	2000	Brunt vann	59°57.500'	10°37.406			10,0
6	1	Årungen	23.okt.19	2000	Landbruk, brunt vann, høy turbiditet, høy vannføring	59°42'050	10°44'19	114		10,0
7	2	Gjersjøen	23.okt.19	2000	Skogområde, brunt vann	59°45'294	10°46'439	103,0		10,7
8	3	Kolbotntjernet	23.okt.19	2000	Algete og brunt vann	59°48'35	10°47'58	143		8,9
9	4	Sværsvann	23.okt.19	2000	Brunt vann	59°49'041	10°53'225	20,3		7,2
10	5	Østensjøvann	23.okt.19	2000	Næringsrik, mye fugl, kloakk	59°49'04	10°53'22	143		8,6
11	6	Solbergvannet	23.okt.19	2000	Organisk jord, brunt vann	59°54'04	10°51'95	14,1		7,6
12	7	Lutvann	23.okt.19	2000	Skog, lite nedbørsfelt, klart vann	59°55'19	10°52'62	24,9		9,7
13	8	Maridalsvannet	23.okt.19	2000	Klart vann, råvannskilde	59°58'09	10°47'06	12,3		9,7
14	9	Akerselva	23.okt.19	2000	Klart vann, Urbant	59°54'79	10°45'44	15,6		10,0

EXAMPLE 1.3: *Estimating the reliability of water analyses*
Your laboratory returns the following water analysis:

pH = 8.22
EC = 290 µS/cm

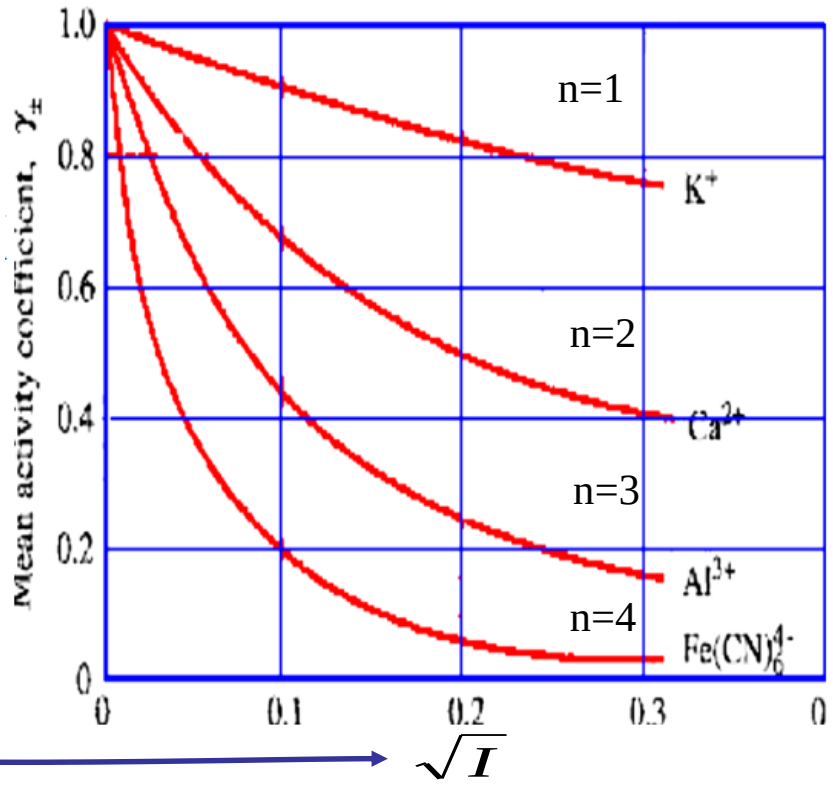
Na^+	K^+	Mg^{2+}	Ca^{2+}	Cl^-	HCO_3^-	SO_4^{2-}	NO_3^-	
13.7	1.18	3.2	42.5	31.2	79.9	39	1.3	mg/l

Is this a reliable analysis?

Activity

- $\{X\} = \gamma_X \cdot [X]$
  - $\{X\}$ is the activity to X
  - $[X]$ is the concentration to X
  - γ_X is the activity coefficient to X
    - γ_X is dimensionless
    - It is determined by:
      - The diameter (å) of the hydrated X
      - Its valence (n_X)
      - The ionic strength (I)

Not possible to calculate further than I=0.1



- when $I \rightarrow 0$ $\gamma \rightarrow 1$
  when $I < 10^{-5}$M $\gamma \approx 1$

Activity

$$I = \mu = \tfrac{1}{2}([A]n_A^2 + [B]n_B^2 + [C]n_C^2 + \ldots.) = \tfrac{1}{2}\Sigma\,[X]n_X^2$$

"I" is expressed in mol/L

Molar of the salt give rise to an I equals:

AgCl: $\tfrac{1}{2}(c\cdot 1^2 + c\cdot 1^2) = \tfrac{1}{2}\cdot 2c = 1c$

$Ba(IO_3)_2$: $\tfrac{1}{2}(c\cdot 2^2 + 2c\cdot 1^2) = \tfrac{1}{2}\cdot 6c = 3c$

$BaSO_4$: $\tfrac{1}{2}(c\cdot 2^2 + c\cdot 2^2) = \tfrac{1}{2}\cdot 8c = 4c$

$Al(NO_3)_3$: $\tfrac{1}{2}(c\cdot 3^2 + 3c\cdot 1^2) = \tfrac{1}{2}\cdot 12c = 6c$

I can be roughly estimated based on the amount of solved material (TDS):

$$I = 2.5\cdot 10^{-5}\cdot \text{TDS (mg/L)}$$

Debye Huckel (DH) equation

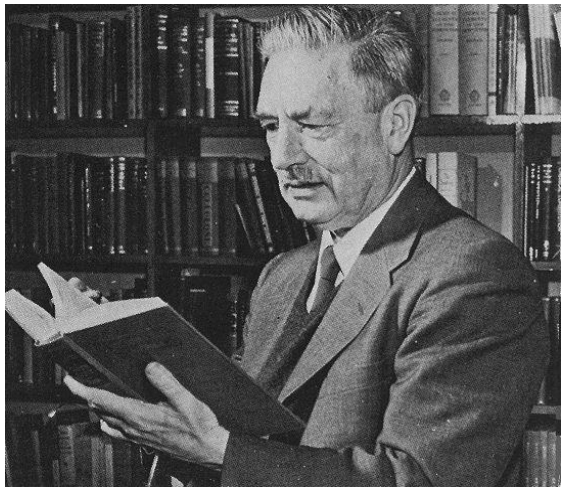
- For ionic strengths (I) < 0.1 M the γ_X can be calculated by means of the e.g. *Debye Huckel* equation:

I < 0.1 M $$-\log \gamma_x = 0.5 n_x^2 \frac{\sqrt{I}}{(1 + 0.33 \mathring{a}_x \sqrt{I})}$$

I < 0.005 M $$(1 + 0.33 \mathring{a}_x \sqrt{0.005}) \approx 1$$

$$-\log \gamma_x = 0.5 n_x^2 \sqrt{I}$$

  - 0.5 & 0.33 are temperature dependent table values
    - Presented values are for 25° C
  - $\mathring{a}_X$ is a table value for the specie in question



Species	å
H_3O^+	9
$Na(H_2O)_6^+$	4
$K(H_2O)_6^+$	3
$Cl(H_2O)_6^-$	3
$Mg(H_2O)_6^{2+}$	8
$Ca(H_2O)_6^{2+}$	6
$Ni(H_2O)_6^{2+}$	6
$Cu(H_2O)_4^+$	6
$Zn(H_2O)_4^{2+}$	6
$Pb(H_2O)_6^{2+}$	5
$Al(H_2O)_6^{2+}$	9
$Fe(H_2O)_6^{2+}$	9

Calculated vs. Measured conductivity

- Calculate:

  μM → μeq/L

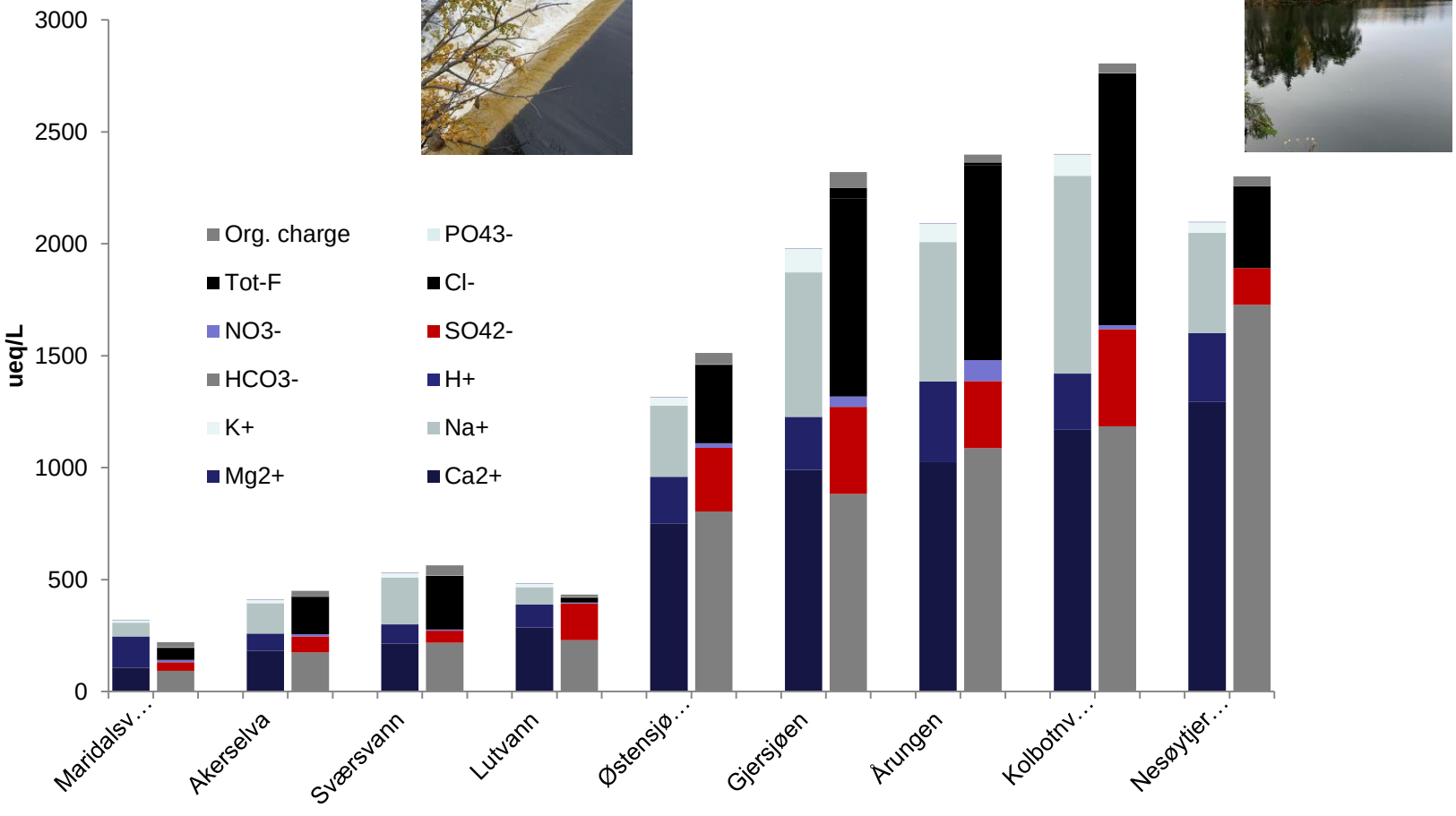
  Ionic strength (I)

  Activity {x}

  Specific conductivity → $SC_X = \Lambda^0_m \ \gamma_X \ m$

  Add all the specific conductivities

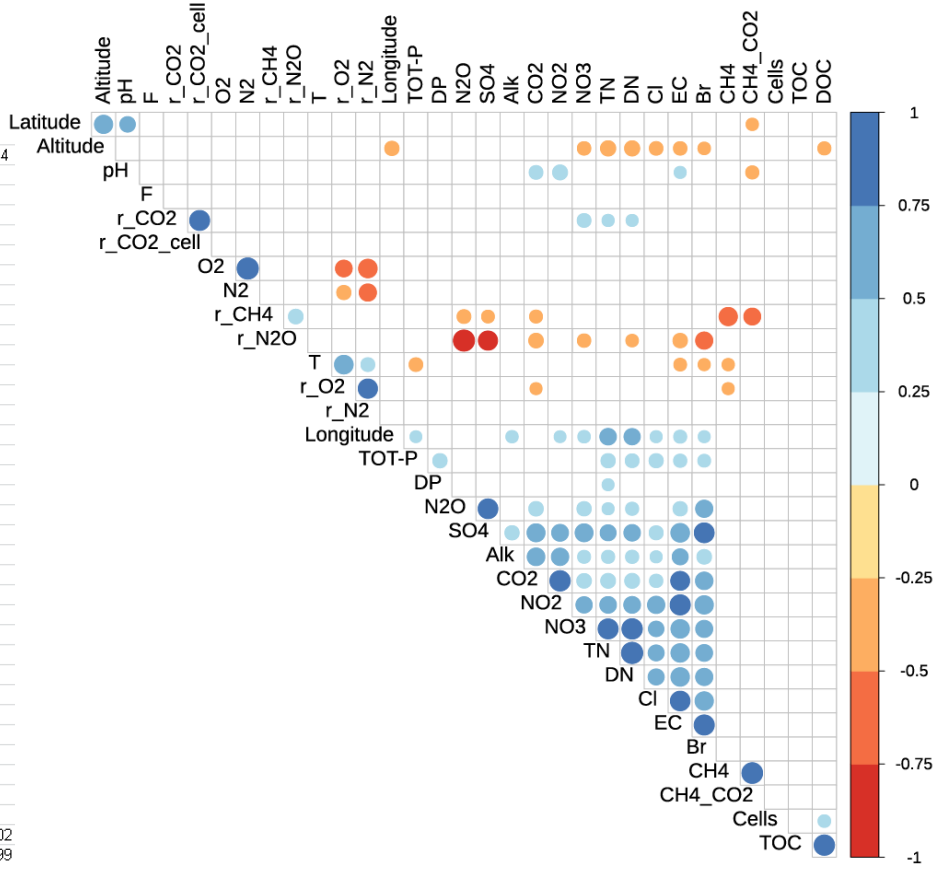
  Compare measured with specific conductivity


3000
2500
2000
1500
1000
500
0
ueq/L
Org. charge
PO43-
Tot-F
Cl-
NO3-
SO42-
HCO3-
H+
K+
Na+
Mg2+
Ca2+
Maridalsv…
Akerselva
Sværsvann
Lutvann
Østensjø…
Gjersjøen
Årungen
Kolbotnv…
Nesøytjer…

Statistical analysis

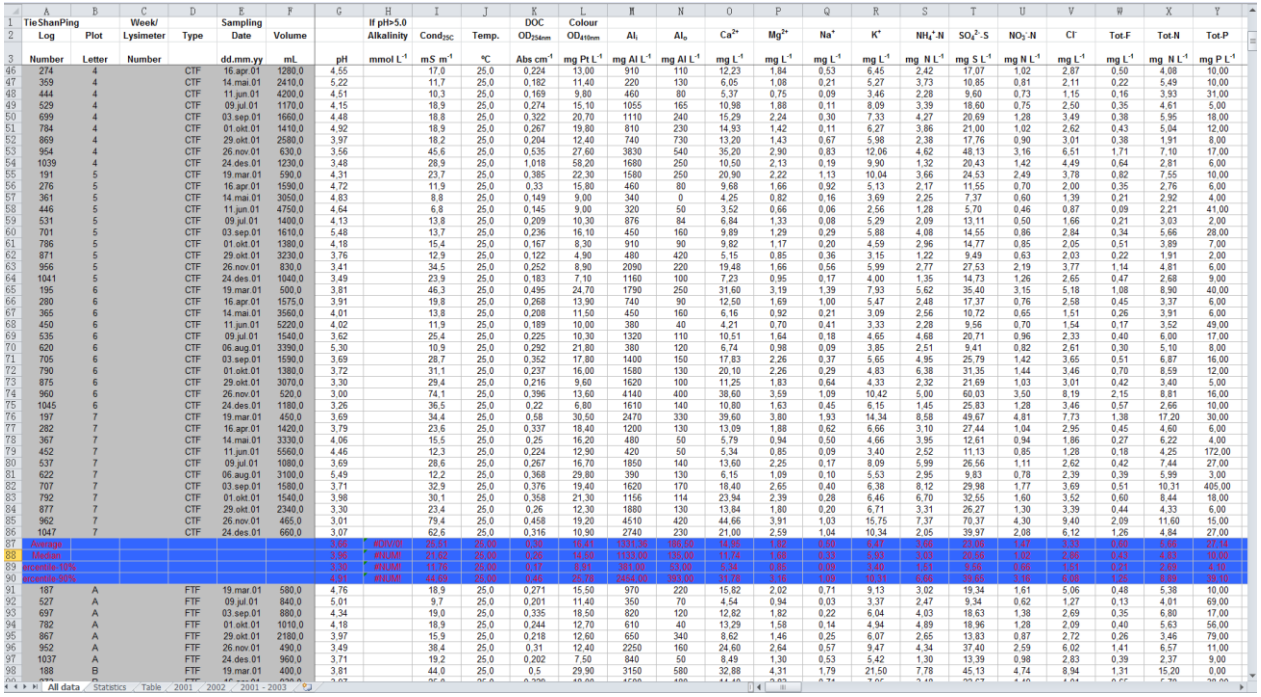
- Correlation matrix
  - Identify parameters that are directly correlated or co-variate

	H+	sUVa	SAR	DOC	Ca2+	Mg2+	Na+	K+	SO42-	NO3-	Cl-	Free PO4
sUVa	0,806											
	0,000											
SAR	0,772	0,852										
	0,000	0,000										
DOC	0,842	0,867	0,953									
	0,000	0,000	0,000									
Ca2+	-0,301	-0,177	-0,046	-0,139								
	0,052	0,262	0,774	0,381								
Mg2+	-0,434	-0,344	-0,254	-0,322	0,934							
	0,004	0,026	0,105	0,038	0,000							
Na+	-0,265	-0,179	-0,062	-0,155	0,816	0,822						
	0,090	0,256	0,698	0,327	0,000	0,000						
K+	-0,234	-0,140	-0,031	-0,048	0,834	0,832	0,815					
	0,136	0,378	0,845	0,761	0,000	0,000	0,000					
SO42-	0,365	0,587	0,716	0,641	0,425	0,239	0,444	0,450				
	0,017	0,000	0,000	0,000	0,005	0,128	0,003	0,003				
NO3-	-0,246	-0,140	-0,143	-0,161	0,381	0,539	0,476	0,621	0,186			
	0,116	0,378	0,366	0,308	0,013	0,000	0,001	0,000	0,239			
Cl-	-0,456	-0,405	-0,316	-0,393	0,691	0,764	0,931	0,749	0,213	0,542		
	0,002	0,008	0,041	0,010	0,000	0,000	0,000	0,000	0,176	0,000		
Free PO4	0,356	0,647	0,576	0,479	0,047	-0,086	0,025	0,005	0,655	0,072	-0,186	
	0,021	0,000	0,000	0,001	0,770	0,588	0,873	0,973	0,000	0,651	0,238	
HCO3	-0,500	-0,445	-0,377	-0,431	0,841	0,846	0,608	0,607	0,023	0,222	0,600	-0,202
	0,001	0,003	0,014	0,004	0,000	0,000	0,000	0,000	0,883	0,158	0,000	0,199



Multivariate statistics

- How to interpret information in a data matrix of 1000 samples with typically 20 – 30 parameters



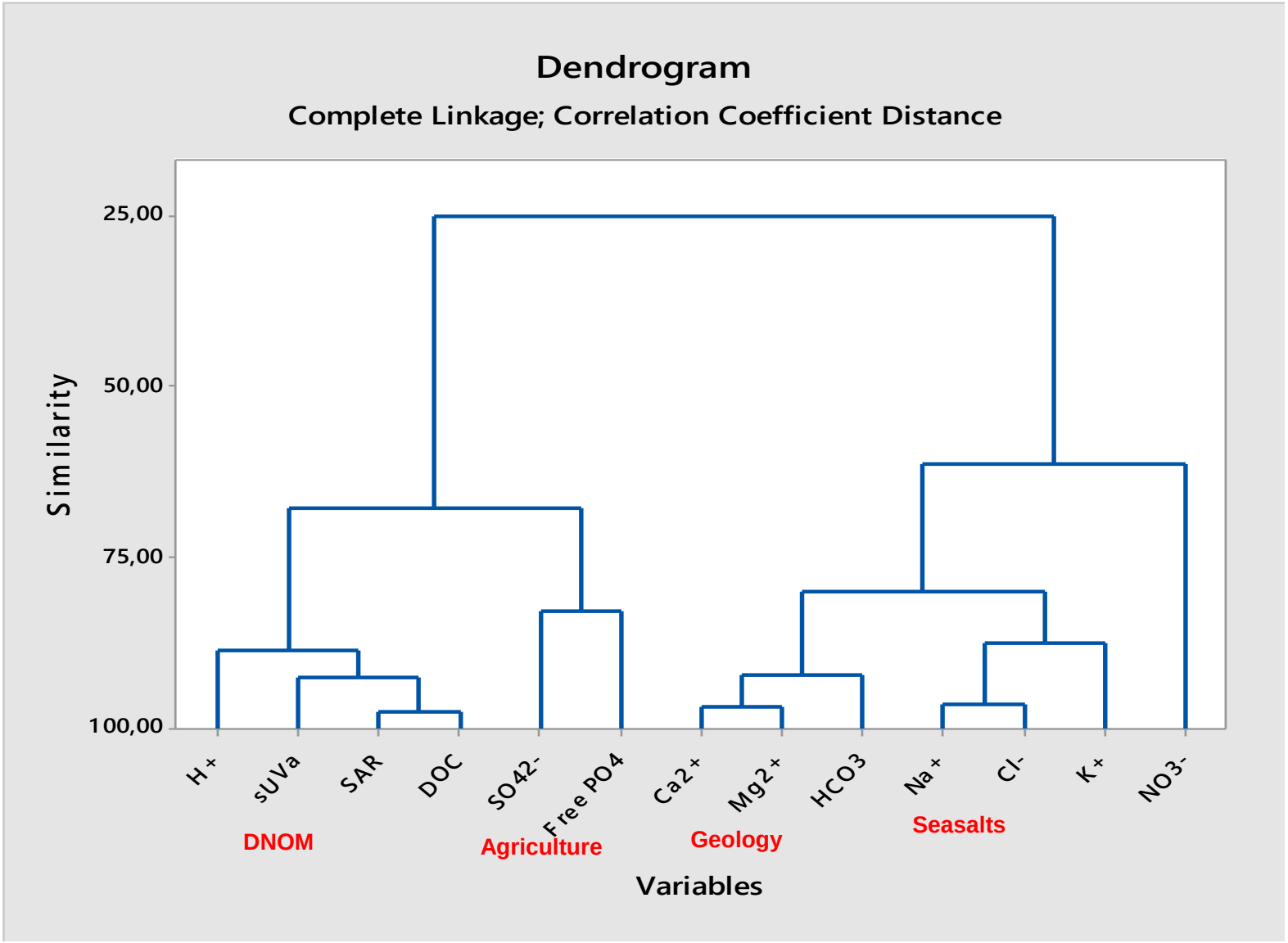
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1	TieShanPing		Week/		Sampling			If pH>5.0			DOC	Colour													
2	Log	Plot	Lysimeter	Type	Date	Volume		Alkalinity	$Cond_{25C}$	Temp.	OD_{254nm}	OD_{410nm}	Al_i	Al_o	Ca^{2+}	Mg^{2+}	Na^+	K^+	NH_4^+-N	SO_4^{2-}-S	NO_3^--N	Cl^-	Tot-F	Tot-N	Tot-P
3	Number	Letter	Number		dd.mm.yy	mL	pH	mmol L^{-1}	mS m^{-1}	°C	Abs cm^{-1}	mg Pt L^{-1}	mg Al L^{-1}	mg Al L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg N L^{-1}	mg S L^{-1}	mg N L^{-1}	mg L^{-1}	mg L^{-1}	mg N L^{-1}	mg P L^{-1}
46	274	4		CTF	16.apr.01	1280,0	4,55		17,0	25,0	0,224	13,00	910	110	12,23	1,84	0,53	6,45	2,42	17,07	1,02	2,87	0,50	4,08	10,00
47	359	4		CTF	14.mai.01	2410,0	5,22		11,7	25,0	0,182	11,40	220	130	6,05	1,08	0,21	5,27	3,73	10,85	0,81	2,11	0,22	5,49	10,00
48	444	4		CTF	11.jun.01	4200,0	4,51		10,3	25,0	0,169	9,80	460	80	5,37	0,75	0,09	3,46	2,28	9,60	0,73	1,15	0,16	3,93	31,00
49	529	4		CTF	09.jul.01	1170,0	4,15		18,9	25,0	0,274	15,10	1055	165	10,98	1,88	0,11	8,09	3,39	18,60	0,75	2,50	0,35	4,61	5,00
50	699	4		CTF	03.sep.01	1660,0	4,48		18,8	25,0	0,322	20,70	1110	240	15,29	2,24	0,30	7,33	4,27	20,69	1,28	3,49	0,38	5,95	18,00
51	784	4		CTF	01.okt.01	1410,0	4,92		18,9	25,0	0,267	19,80	810	230	14,93	1,42	0,11	6,27	3,86	21,00	1,02	2,62	0,43	5,04	12,00
52	869	4		CTF	29.okt.01	2580,0	3,97		18,2	25,0	0,204	12,40	740	730	13,20	1,43	0,67	5,98	2,38	17,76	0,90	3,01	0,38	1,91	8,00
53	954	4		CTF	26.nov.01	630,0	3,56		45,6	25,0	0,535	27,60	3830	540	35,20	2,90	0,83	12,06	4,62	48,13	3,16	6,51	1,71	7,10	17,00
54	1039	4		CTF	24.des.01	1230,0	3,48		28,9	25,0	1,018	58,20	1680	250	10,50	2,13	0,19	9,90	1,32	20,43	1,42	4,49	0,64	2,81	6,00
55	191	5		CTF	19.mar.01	590,0	4,31		23,7	25,0	0,386	22,30	1580	250	20,90	2,22	1,13	10,04	3,66	24,53	2,49	3,78	0,82	7,55	10,00
56	276	5		CTF	16.apr.01	1590,0	4,72		11,9	25,0	0,33	15,80	460	80	9,68	1,66	0,92	5,13	2,17	11,55	0,70	2,00	0,35	2,76	6,00
57	361	5		CTF	14.mai.01	3050,0	4,83		8,8	25,0	0,149	9,00	340	0	4,25	0,82	0,16	3,69	2,25	7,37	0,60	1,39	0,21	2,92	4,00
58	446	5		CTF	11.jun.01	4750,0	4,64		6,8	25,0	0,145	9,00	320	50	3,52	0,66	0,06	2,56	1,28	5,70	0,46	0,87	0,09	2,21	41,00
59	531	5		CTF	09.jul.01	1400,0	4,13		13,8	25,0	0,209	10,30	876	84	6,84	1,33	0,08	5,29	2,09	13,11	0,50	1,66	0,21	3,03	2,00
60	701	5		CTF	03.sep.01	1610,0	5,48		13,7	25,0	0,236	16,10	450	160	9,89	1,29	0,29	5,88	4,08	14,55	0,86	2,84	0,34	5,66	28,00
61	786	5		CTF	01.okt.01	1380,0	4,18		15,4	25,0	0,167	8,30	910	90	9,82	1,17	0,20	4,59	2,96	14,77	0,85	2,05	0,51	3,89	7,00
62	871	5		CTF	29.okt.01	3230,0	3,76		12,9	25,0	0,122	4,90	480	420	5,15	0,85	0,36	3,15	1,22	9,49	0,63	2,03	0,22	1,91	2,00
63	956	5		CTF	26.nov.01	830,0	3,41		34,5	25,0	0,252	8,90	2090	220	19,48	1,66	0,56	5,99	2,77	27,53	2,19	3,77	1,14	4,81	6,00
64	1041	5		CTF	24.des.01	1040,0	3,49		23,9	25,0	0,183	7,10	1160	100	7,23	0,95	0,17	4,00	1,35	14,73	1,26	2,65	0,47	2,68	9,00
65	195	6		CTF	19.mar.01	500,0	3,81		46,3	25,0	0,495	24,70	1790	250	31,60	3,19	1,39	7,93	5,62	35,40	3,15	5,18	1,08	8,90	40,00
66	280	6		CTF	16.apr.01	1575,0	3,91		19,8	25,0	0,268	13,90	740	90	12,50	1,69	1,00	5,47	2,48	17,37	0,76	2,58	0,45	3,37	6,00
67	365	6		CTF	14.mai.01	3560,0	4,01		13,8	25,0	0,208	11,50	450	160	6,16	0,92	0,21	3,09	2,56	10,72	0,65	1,51	0,26	3,91	6,00
68	450	6		CTF	11.jun.01	5220,0	4,02		11,9	25,0	0,189	10,00	380	40	4,21	0,70	0,41	3,33	2,28	9,56	0,70	1,54	0,17	3,52	49,00
69	535	6		CTF	09.jul.01	1540,0	3,62		25,4	25,0	0,225	10,30	1320	110	10,51	1,64	0,18	4,65	4,68	20,71	0,96	2,33	0,40	6,00	17,00
70	620	6		CTF	06.aug.01	3390,0	5,30		10,9	25,0	0,292	21,80	380	120	6,74	0,98	0,09	3,85	2,51	9,41	0,82	2,61	0,30	5,10	8,00
71	705	6		CTF	03.sep.01	1590,0	3,69		28,7	25,0	0,352	17,80	1400	150	17,83	2,26	0,37	5,65	4,95	25,79	1,42	3,65	0,51	6,87	16,00
72	790	6		CTF	01.okt.01	1380,0	3,72		31,1	25,0	0,237	16,00	1580	130	20,10	2,26	0,29	4,83	6,38	31,35	1,44	3,46	0,70	8,59	12,00
73	875	6		CTF	29.okt.01	3070,0	3,30		29,4	25,0	0,216	9,60	1620	100	11,25	1,83	0,64	4,33	2,32	21,69	1,03	3,01	0,42	3,40	5,00
74	960	6		CTF	26.nov.01	520,0	3,00		74,1	25,0	0,396	13,60	4140	400	38,60	3,59	1,09	10,42	5,00	60,03	3,50	8,19	2,15	8,81	16,00
75	1045	6		CTF	24.des.01	1180,0	3,26		36,5	25,0	0,22	6,80	1610	140	10,80	1,63	0,45	6,15	1,45	25,83	1,28	3,46	0,57	2,66	10,00
76	197	7		CTF	19.mar.01	450,0	3,69		34,4	25,0	0,58	30,50	2470	330	39,60	3,80	1,93	14,34	8,58	49,67	4,81	7,73	1,38	17,20	30,00
77	282	7		CTF	16.apr.01	1420,0	3,79		23,6	25,0	0,337	18,40	1200	130	13,09	1,88	0,62	6,66	3,10	27,44	1,04	2,95	0,45	4,60	6,00
78	367	7		CTF	14.mai.01	3330,0	4,06		15,5	25,0	0,25	16,20	480	50	5,79	0,94	0,50	4,66	3,95	12,61	0,94	1,86	0,27	6,22	4,00
79	452	7		CTF	11.jun.01	5560,0	4,46		12,3	25,0	0,224	12,90	420	50	5,34	0,85	0,09	3,40	2,52	11,13	0,85	1,28	0,18	4,25	172,00
80	537	7		CTF	09.jul.01	1080,0	3,69		28,6	25,0	0,267	16,70	1850	140	13,60	2,25	0,17	8,09	5,99	26,56	1,11	2,62	0,42	7,44	27,00
81	622	7		CTF	06.aug.01	3100,0	5,49		12,2	25,0	0,368	29,80	390	130	6,15	1,09	0,10	5,53	2,95	9,83	0,78	2,39	0,39	5,99	3,00
82	707	7		CTF	03.sep.01	1580,0	3,71		32,9	25,0	0,376	19,40	1620	170	18,40	2,65	0,40	6,38	8,12	29,98	1,77	3,69	0,51	10,31	405,00
83	792	7		CTF	01.okt.01	1540,0	3,98		30,1	25,0	0,358	21,30	1156	114	23,94	2,39	0,28	6,46	6,70	32,55	1,60	3,52	0,60	8,44	18,00
84	877	7		CTF	29.okt.01	2340,0	3,30		23,4	25,0	0,26	12,30	1880	130	13,84	1,80	0,20	6,71	3,31	26,27	1,30	3,39	0,44	4,33	6,00
85	962	7		CTF	26.nov.01	465,0	3,01		79,4	25,0	0,458	19,20	4510	420	44,66	3,91	1,03	15,75	7,37	70,37	4,30	9,40	2,09	11,60	15,00
86	1047	7		CTF	24.des.01	660,0	3,07		62,6	25,0	0,316	10,90	2740	230	21,00	2,59	1,04	10,34	2,05	39,97	2,08	6,12	1,26	4,84	27,00
87	Average						3,66	#DIV/0!	26,51	25,00	0,30	16,41	1331,36	186,00	14,95	1,82	0,50	6,47	3,68	23,06	1,47	3,33	0,60	5,66	27,14
88	Median						3,96	#NUM!	21,62	25,00	0,26	14,50	1133,00	135,00	11,78	1,68	0,33	5,93	3,03	20,56	1,02	2,86	0,43	4,63	10,00
89	ercentile-10%						3,33	#NUM!	13,76	25,00	0,17	8,70	581,00	53,00	5,34	0,87	0,09	3,40	1,61	9,09	0,80	1,63	0,21	2,69	4,70
90	ercentile-90%						4,01	#NUM!	44,69	25,00	0,46	26,79	2494,00	393,00	31,76	3,16	1,09	10,31	5,66	39,55	3,16	6,08	1,26	8,89	59,10
91	187	A		FTF	19.mar.01	580,0	4,76		18,9	25,0	0,271	15,50	970	220	15,82	2,02	0,71	9,13	3,02	19,34	1,61	5,06	0,48	5,38	10,00
92	527	A		FTF	09.jul.01	840,0	5,01		9,7	25,0	0,201	11,40	350	70	4,54	0,94	0,03	3,37	2,47	9,34	0,62	1,27	0,13	4,01	69,00
93	697	A		FTF	03.sep.01	880,0	4,34		19,0	25,0	0,335	18,50	820	120	12,82	1,82	0,22	6,04	4,03	18,63	1,38	2,69	0,35	6,80	17,00
94	782	A		FTF	01.okt.01	1010,0	4,18		18,9	25,0	0,244	12,70	610	40	13,29	1,58	0,14	4,94	4,89	18,96	1,28	2,09	0,40	5,63	56,00
95	867	A		FTF	29.okt.01	2180,0	3,97		15,9	25,0	0,218	12,60	650	340	8,62	1,46	0,25	6,07	2,65	13,83	0,87	2,72	0,26	3,46	79,00
96	952	A		FTF	26.nov.01	490,0	3,49		38,4	25,0	0,31	12,40	2250	160	24,60	2,64	0,57	9,47	4,34	37,40	2,59	6,02	1,41	6,57	11,00
97	1037	A		FTF	24.des.01	960,0	3,71		19,2	25,0	0,202	7,50	840	50	8,49	1,30	0,53	5,42	1,30	13,39	0,98	2,83	0,39	2,37	9,00
98	188	B		FTF	19.mar.01	400,0	3,81		44,0	25,0	0,5	29,90	3150	580	32,88	4,31	1,79	21,50	7,78	45,13	4,74	8,94	1,31	15,20	0,00

All data / Statistics / Table / 2001 / 2002 / 2001 - 2003

Cluster analysis

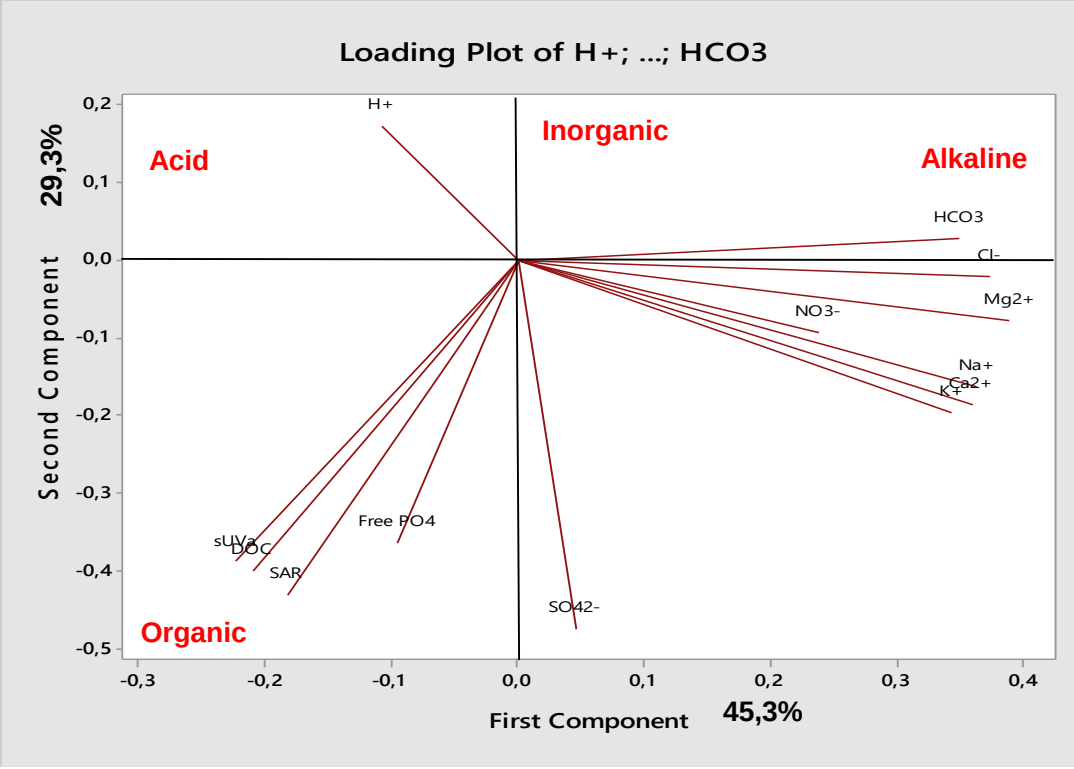
- Organizing parameters that co-variate in clusters
  - Identify
    - Links between parameters and groups of parameters
    - Identify key explanatory factors
    - General patterns

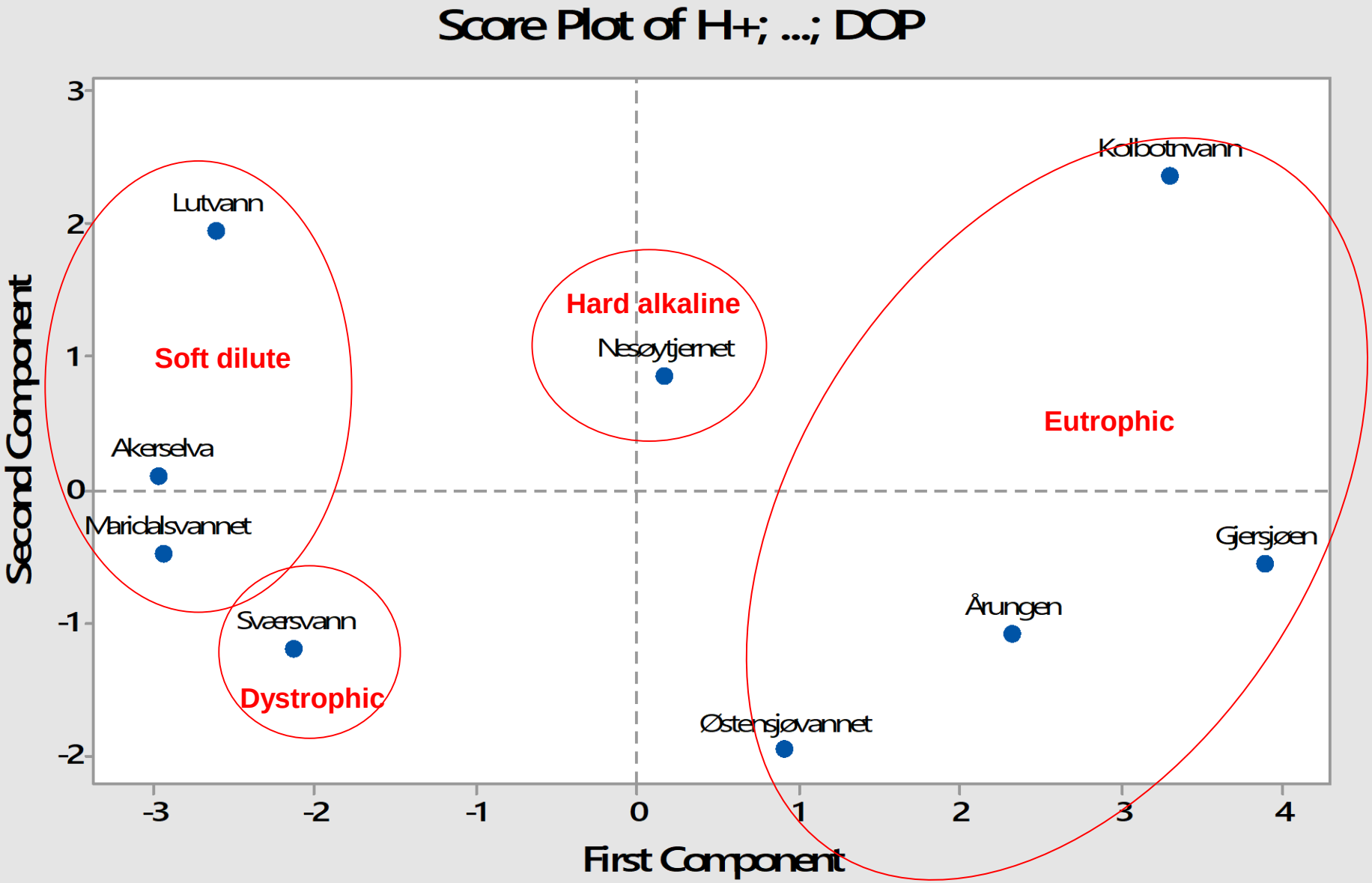
Cluster analysis



Principal Component Analysis

- Makes an n-dimentioal graph of your n parameters
- Identifies the greatest variation in the swarm of data points and draws the PC1 through its axis.
- Identifies the next PC perpendicular to the previous
- Produce loading plots that are projections of the points to the PC plane




Score Plot of H+; ...; DOP
Second Component
First Component
3
2
1
0
-1
-2
-3
-2
-1
0
1
2
3
4
Lutvann
Soft dilute
Akerselva
Maridalsvannet
Sværsvann
Dystrophic
Hard alkaline
Nesøytjernet
Kolbotnvann
Eutrophic
Gjersjøen
Årungen
Østensjøvannet

Szopińska et al., 2016