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Oskarshamn site investigation

Sampling of shallow ground water at Simpevarp 2004

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Medins Biologi AB

November 2006

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This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the authors and do not necessarily coincide with those of the client.

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Abstract

In 2004 sampling of shallow ground water in water wells in soil has been performed at 21 sites within the site investigation area at Oskarshamn. The purpose of the activity is to characterise the shallow ground water in the site investigation area.

Some physical and chemical parameters were measured directly in the field but most parameters were analysed at different laboratories. The ground water sampling activity consisted of two different programmes, chemical programme class 3 and chemical programme class 5. The class 5 programme included more components to be analysed.

The large number of sites and parameters analysed have generated a large amount of data, which will later be used for advanced analysis and modelling. In this report the evaluation aims to give a simple overview of the results and to describe the quality of the data sampled from January 2004 to December 2004.

Some nonconformities from the activity plan occurred. The most important one is that it was not possible to sample the sites at all occasions. Three ground water wells in the Laxemar area were not possible to sample at all, and some other wells sometimes lacked enough water, which limited the number of components that could be analysed. Another type of nonconformity was that measurements of water temperature in the field were not performed during 2004. Likewise field measurements of pH were not performed in some of wells during sampling in September.

The results showed a quite large variation between the different wells. The ion concentrations and conductivity ranged from what can be termed as low to high values. Likewise the concentration of HCO_3 varied extensively throughout the investigation area with high concentrations in most wells. In one well the concentration of HCO_3 was lower with an indication of a problem with acidification in the ground water.

As with the ions measurements on environmental metals and trace elements varied quite much between the wells. High concentration of lead in some of the wells indicated pollution but since the concentration of lead in the wells had a similar relation to aluminium as most other elements it was argued that the high concentration of lead probably can be explained by the natural composition of minerals in the Simpevarp area.

The average ratios of isotopes of boron, chlorine, strontium and oxygen ($^{10}\text{B}/^{11}\text{B}$, ^{37}Cl , $^{87}\text{Sr}/^{86}\text{Sr}$ and ^{18}O) were similar in most wells and there seems to be low variation in the investigated areas. The isotopes of carbon and sulphur varied more between the different wells with the greatest variation in sulphur.

The average hydrogen isotope ratios of deuterium (dD) and tritium (^3H) had similar values in most wells. However, one well differed, with a markedly lower ratio for tritium. The ratios of deuterium (dD) correlated well with the ratios of ^{18}O but the linear relation differed markedly from the "Global Meteoric Line" which is based on precipitation data.

All measurements on thorium and of uranium-235 were below the reporting limits. The concentration of uranium-238 and uranium-234 was below or just over the reporting limit in most wells. Three of the wells differed with considerably higher concentrations for one or both of these uranium isotopes.

The concentration of radium was close to the reporting limit in the wells and there seems to be little variation in the investigation areas. The activity of radon varied to some extent but all values measured can be considered as normal background values for shallow ground water.

The concentration of nitrate varied with considerable higher concentration in some of the wells. However, the concentration in all wells can be termed as very low. Likewise the concentration of phosphorus, silica and sulphur varied with considerably higher values in some of the wells. The concentration of dissolved organic carbon varied with values up to 19 mg/l. This is only slightly lower than most surface waters in the area.

Sammanfattning

Provtagning av yttligt grundvatten i jordrör har under 2004 skett vid 21 platser inom platsundersökningsområdet vid Simpevarp.

Några fysiska och kemiska parametrar har mätts direkt i fält men merparten av de insamlade parametrarna är resultatet av laboratorieanalyser. Aktiviteten bestod av två olika program, klass 3 och 5, med fler analyserade parametrar under de veckor då klass 5 programmet följdes.

Det stora antalet platser och analyserade parametrar har genererat en stor mängd data som senare kommer att användas för avancerad analys och modellering. I denna rapport har utvärderingen syftat till att ge en enkel översikt över resultaten och att beskriva kvaliteten av de data som samlats in mellan januari och december 2004.

En del avvikelser från aktivitetsplanen har skett. Viktigast är att det inte alltid varit möjligt att ta prover vid alla stationer. Tre av grundvattenrören inom Laxemarsområdet har inte kunnat provtas alls och vid andra stationer har det ibland funnits för lite vatten för att kunna utföra alla planerade analyser. En annan typ av avvikelse mot planen var att vattentemperaturen inte vid något tillfälle mättes i fält under året. Likadant mättes inte pH värdet i fält i en del av grundvattenrören vid provtagningarna under september.

Resultaten av undersökningarna visade på en ganska stor variation mellan de olika grundvattenrören i området. Koncentrationen av joner och konduktiviteten varierade mellan vad som kan betecknas som låga till höga värden. Likadant varierade koncentrationen av HCO_3 mycket med höga koncentrationer vid de flesta provplatserna. I ett av grundvattenrören var koncentrationen så låg att resultatet indikerade problem med försurning av grundvattnet.

Liksom för jonerna varierade värdena för miljömetaller och spårelement ganska mycket mellan de olika provplatserna. En hög koncentration av bly vid några av platserna indikerade någon sorts förorening. Men eftersom relationen mellan koncentrationen av bly och aluminium liknade den som flertalet andra metaller och spårelement hade med aluminium drogs slutsatsen att resultatet med höga blyhalter kan förklaras med mineralets naturliga sammansättning i området.

Isotopkvoterna av bor, klor, strontium och syre ($^{10}\text{B}/^{11}\text{B}$, ^{37}Cl , $^{87}\text{Sr}/^{86}\text{Sr}$ and ^{18}O) var liknande vid de flesta provplatserna och det verkar vara en liten variation inom undersökningsområdet. Isotoperna av kol och svavel varierade mer med en något större variation för svavel.

Medelvärdena av väteisotoperna deuterium och tritium var liknande i de flesta grundvattenrören. Resultatet från ett av rören skiljde sig dock med en märkbart lägre kvot för tritium. Kvoterna av deuterium var väl korrelerade till kvoterna av ^{18}O men den linjära relationen skiljde sig märkbart från "the Global Meteoric Line" vilken baseras på data från nederbörd.

Alla analyser av thorium och av uran-235 var under rapporteringsgränsen men analyserna av uran-238 and uran-234 hade värden under eller strax över rapporteringsgränsen vid de flesta provplatserna. Tre av provplatserna skiljde sig dock med ett betydligt högre värde för det ena eller bägge uranisotoperna.

Koncentrationen av radium var nära rapporteringsgränsen vid de olika provplatserna och variationen verkar vara liten inom undersökningsområdet. Aktiviteten av radon varierade i viss utsträckning men alla uppmätta värden kan betraktas som normala bakgrundsvärden för grundvatten.

Koncentrationen av nitrat varierade med betydligt högre värden i några av grundvattenrören. Värdena kan dock klassas som mycket låga vid alla platser. Även koncentrationen av fosfor, kisel och sulfat varierade med betydligt högre värden vid vissa av provplatserna. Koncentrationen av löst organiskt kol (DOC) varierade med värden upp till 19 mg/l. Detta är endast något lägre än innehållet i de flesta ytvatten i området.

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1 Introduction

This document reports the data gained by the sampling of shallow ground water in the areas of Ävrö, Hålö, Simpevarp peninsula and Laxemar, which is one of the activities performed within the site investigation at Oskarshamn. The work was carried out in accordance with activity plans AP PS 400-03-054 and AP PS 400-04-077. In Table 1-1 controlling documents for performing this activity are listed. The activity plans are SKB's internal controlling documents.

Within the site investigation area at Simpevarp water has been sampled from shallow ground water wells in soil. During 2004 sampling was performed at 21 sites (Figure 1-1) on up to four occasions and the water was analysed for a large number of parameters. All original results have been stored in the primary database SICADA. The results are traceable by the activity plan number. The data in the data base will later be used for further interpretation (modelling).

Table 1-1. Controlling documents for the performance of the activity.

Activity plan	Number	Version
Jordrörsprovtagning 2004 (Ävrö, Hålö och Simpevarphalvön)	AP PS 400-03-054	1.0
Vattenprovtagning i jordrör, Laxemar 2004-2006	AP PS 400-04-077	1.0

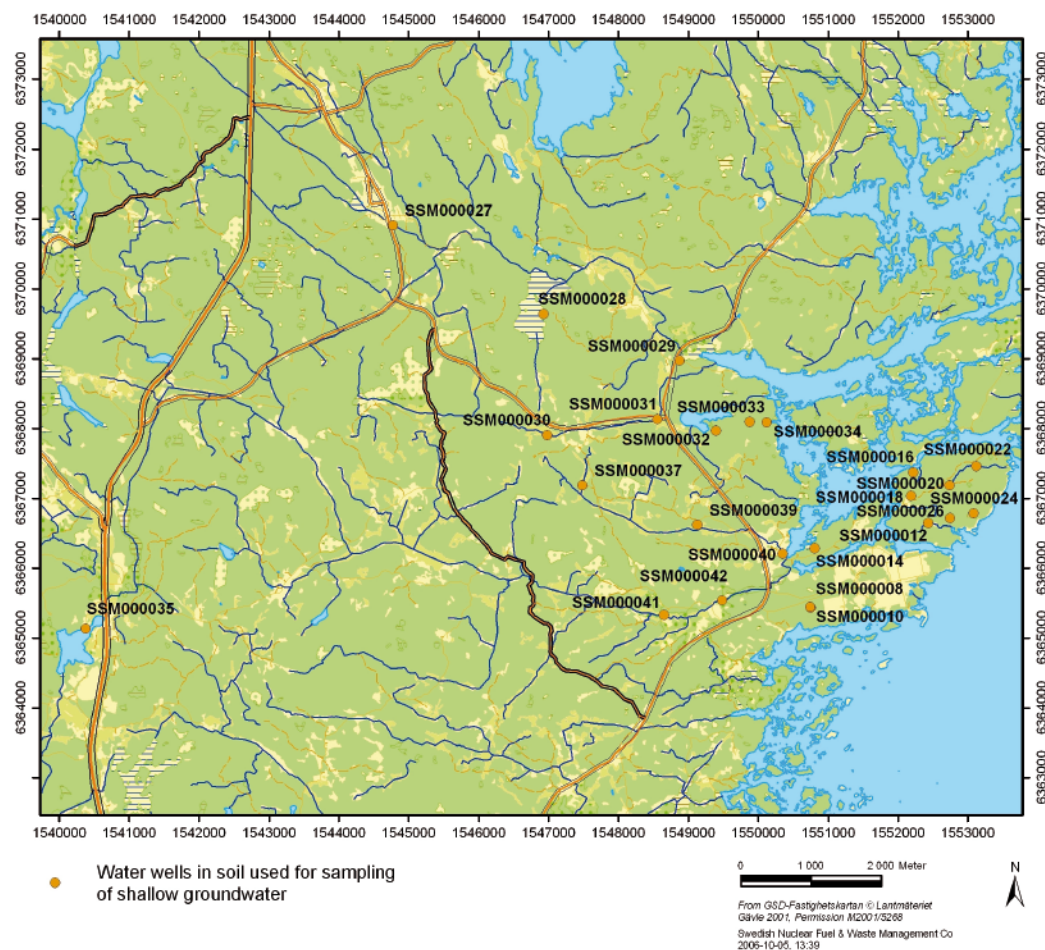


Figure 1-1. The site investigation area and water wells in soil used for sampling of shallow ground-water. Three water wells in the Laxemar area (PSM000028, PSM000032 and PSM000033) were not possible to sample.

2 Objective and scope

The purpose of the activity is to characterise the shallow ground water in the site investigation area. This document reports the data gained by the sampling of ground water in two areas; Ävrö, Hålö, and Simpevarp peninsula area and in the Laxemar area. In the former area sampling was performed at ten different ground water wells, at four occasions during 2004 and in the latter area sampling was performed at eleven ground water wells at two occasions during the autumn and winter 2004.

Some physical and chemical parameters were measured directly on the spot. Water samples were then taken for analysis of further parameters. The samples were later sent to different laboratories for the analysis.

The ground water sampling activity consisted of two different programmes, chemical programme class 3 and chemical programme class 5. The class 5 programme included more components to be analysed than the class 3 (Table 2-1). Sometimes it was not possible to get a sufficient amount of water for analysis of all components, so a priority order for both programmes was set up (Table 2-1). A time schedule for both areas and programmes can be viewed in Appendix 2.

The large number of sites and parameters analysed have generated a large amount of data, which will later be used for advanced analysis and modelling. In this report the evaluation aims to give a simple overview of the results and to describe the quality of the data sampled from January 2004 to December 2004.

Table 2-1. Analysed components and priority order for chemical programme class 3 and 5.

Chemical programme class 3		Chemical programme class 5		Chemical programme class 5	
Components	Priority	Components	Priority	Components	Priority
Alkalinity, pH, Conductivity	2	Alkalinity, pH, Conductivity	2	Optional components:	
Anions (F ⁻ , Cl ⁻ , Br ⁻ , SO ₄ ²⁻)	3	Anions (F ⁻ , Cl ⁻ , Br ⁻ , SO ₄ ²⁻)	3	B-10	6
Archive	10	Fe II + Fe (tot)	10	As, In	6
Standard elements	1	NH ₄	11	Environmental metals	6
		S ₂ ⁻	12	Lantanoides	6
<i>Optional components:</i>		Standard elements	1	Trace elements	6
Deuterium, O-18	4	NO ₃ , NO ₂ , NO ₂ +NO ₃ , PO ₄	18	TOC	16
Tritium, Cl-37	5	DOC	17	Cl-37	5
Sr-87	8	Deuterium, O-18	4	Sr-87	8
B-10	6	Tritium	5	C-13, PMC	7
C-13, PMC	7	Archive (acid rinsed)	19	S-34	9
S-34	9	Archive	19	U-, Th-isotopes	13
				Ra-, Rn-isotopes	14

3 Equipment

3.1 Equipment used in the field

Underwater pump (type 12 V Avimex). Used in the field for pumping up water from the ground water wells.

Volume graded five litre containers, used in field as collecting vessels.

pH-meter and thermometer. Used for field measurements.

Field notes.

3.2 Equipment used at the laboratory

Tube pump. Used in the laboratory to filter sampled water.

0.45 μm filter (PALL). Capsule filter used together with the tube pump.

0.45 μm membrane filter. Used together with the tube pump.

4 Execution

4.1 Sites and sampling frequency

The total number of sampled sites was 21, both areas included. In Appendix 1, location coordinates and sample depths for all ground water wells can be viewed. During 2004, sampling was performed at four occasions in the Ävrö, Hälö, and Simpevarp peninsula area. In the Laxemar area sampling was performed two times. A time schedule for both areas and programmes are presented in Appendix 2. Although all sites were meant to be sampled on every occasion, this wasn't always possible due to insufficient amount of water, frozen water and other disturbances (Appendix 3). Sampling was performed by Helen Hultgren, SKB.

4.2 Execution of sampling and treatment of samples

To avoid contamination all sampling was conducted with protective rubber gloves and great care was taken not to contaminate containers or equipment. The day before sampling, each ground water well was visited and water was pumped up, if possible, for at least ten minutes. On the sampling day, the ground water level was sounded and noted down. Field measurements of pH were then performed, before the collecting vessels were filled with water.

After sampling in field the samples were taken to a preparation room where most of the samples were prepared before analysis (Table 4-1 and 4-2). The sample in the collecting bottles was divided into smaller bottles. Many of the samples were then prepared with different types of filtrations and/or different type of conservations. This was conducted with protective rubber gloves to minimise the risk of contamination.

Storing and delivery of samples to the different analysing laboratories are presented in Table 4-3 and 4-4. Some of the samples were sent immediately at the end of each day and some were stored in a refrigerator or freezer till the end of the week, when they were sent to the laboratory.

Table 4-1. Indoor treatments of samples, chemical programme class 3.

Bottle	Number	SKB-label	Components	Filling instructions	Preparation
250 ml	1	green	Alkalinity, pH, Conductivity	Fill up	–
250 ml	1	green	Anions (F ⁻ , Cl ⁻ , Br ⁻ , SO ₄ ²⁻)	Fill up	–
125 ml	1	red	Standard elements and B-10	Fill up	Filtering with membrane filter and add 1 ml concentrated HNO ₃
250 ml	2	green	Archive	Fill 80%	Filtering with "Pallfilter" 0.45 µm
100 ml quadrangular	1	green	Deuterium, O-18	Fill up	–
1,000 ml dried	1	green	Tritium, Cl-37	Flow over once	–
100 ml quadrangular	1	green	Sr-87	Fill up	–
100 ml brown glass	2	green	C-13, PMC	Fill up	–
1,000 ml	1	green	S-34	Fill up	–

Table 4-2. Indoor treatments of samples, chemical programme class 5.

Bottle	Number	SKB-label	Components	Filling instructions	Preparation
250 ml	1	green	Alkalinity, pH, Conductivity	Fill up	–
250 ml	1	green	Anions (F ⁻ , Cl ⁻ , Br ⁻ , SO ₄ ²⁻)	Fill up	–
500 ml acid rinsed PEH bottle	1	red	Fe II + Fe tot	Fill up	Filtering with membrane filter add 5 ml concentrated HCl
Graduated flask reagent rinsed	2		Ammonium	25 ml	–
Winkler bottle	2		S ₂ ⁻	Flow over three times	Filtering with "Pallfilter" 0.45 µm, add 0.5 ml 1M ZnAc and 0.5 ml 1M NaOH
125 ml	1	red	Standard elements, B-10, As, In, environment. metals lantanoides, trace elements	Fill up	Filtering with membrane filter, add 1 ml concentrated HNO ₃
100 ml	1	green	Iodine	Fill up	Filtering with membrane filter
250 ml	1	green	NO ₃ ⁻ , NO ₂ ⁻ , (NO ₂ ⁻ +NO ₃ ⁻), PO ₄ ³⁻	Fill up	Filtering with "Pallfilter" 0.45 µm
250 ml	1	green	DOC	Fill up	Filtering with "Pallfilter" 0.45 µm
250 ml	1	green	TOC	Fill up	
100 ml quadrangular	1	green	Deuterium, O-18	Fill up	–
1,000 ml dried	1	green	Tritium, Cl-37	Flow over once	–
100 ml quadrangular	1	green	Sr-87	Fill up	–
100 ml brown glass	2	green	C-13, PMC	Fill up	–
1,000 ml	1	green	S-34	Fill up	–
100 ml quadrangular	1	green	U-, Th-isotopes	Fill up	–
500 ml PEH bottle		green	Ra-, Rn-isotopes	Fill up	–
250 ml	2	green	Archive	Fill 80%	Filtering with "Pallfilter" 0.45 µm
100 ml	2	red	Archive	Fill 80%	Filtering with membrane filter, add 1 ml concentrated HNO ₃

Table 4-3. Treatments of samples when storing and delivering to analysing laboratory, chemical programme class 3.

Bottle	Number	SKB-label	Components	Storing	Analysing laboratory	Way of delivery
250 ml	1	green	Alkalinity, pH, Conductivity	Refrigerator	Äspö laboratory	Directly
250 ml	1	green	Anions (F ⁻ , Cl ⁻ , Br ⁻ , SO ₄ ²⁻)	Refrigerator	Äspö laboratory	Directly
125 ml	1	red	Standard elements, B-10	Refrigerator	Analytica	Parcel post
250 ml	2	green	Archive	Freezer		–
100 ml quadrangular	1	green	Deuterium, O-18	Refrigerator	IFE, Norway	Parcel post
1,000 ml dried	1	green	Tritium, Cl-37	Refrigerator	Waterloo	Parcel post
100 ml quadrangular	1	green	Sr-87	Refrigerator	IFE, Norway	Parcel post
100 ml brown glass	2	green	C-13, PMC	Refrigerator	Waterloo	Parcel post
1,000 ml	1	green	S-34	Refrigerator	IFE, Norway	Parcel post

Table 4-4. Treatments of samples when storing and delivering to analysing laboratory, chemical programme class 5.

Bottle	Number	SKB-label	Components	Storing	Analysing laboratory	Way of delivery
250 ml	1	green	Alkalinity, pH, Conductivity	Refrigerator	Äspö laboratory	Directly
250 ml	1	green	Anions (F ⁻ , Cl ⁻ , Br ⁻ , SO ₄ ²⁻)	Refrigerator	Äspö laboratory	Directly
500 ml acid rinsed PEH bottle	1	red	Fe II + Fe tot	Refrigerator	Äspö laboratory	Directly
Graduated flask reagent rinsed	2		Ammonium	Refrigerator	Äspö laboratory	Directly
Winkler bottle	2		S ₂ ⁻	Refrigerator	Äspö laboratory	Directly
125 ml	1	red	Standard elements, B-10, As, In, environment. metals lantanoides, trace elements	Refrigerator	Analytica	Parcel post
100 ml	1	green	Iodine	Refrigerator	Analytica	Parcel post
250 ml	1	green	NO ₃ ⁻ , NO ₂ ⁻ , (NO ₂ ⁻ +NO ₃ ⁻), PO ₄ ³⁻	Freezer	Systemekologen	Parcel post
250 ml	1	green	DOC	Freezer	Paavo Ristola	Parcel post
250 ml	1	green	TOC	Freezer	Paavo Ristola	Parcel post
100 ml quadrangular	1	green	Deuterium, O-18	Refrigerator	IFE, Norway	Parcel post
1,000 ml dried	1	green	Tritium, Cl-37	Refrigerator	Waterloo	Parcel post
100 ml quadrangular	1	green	Sr-87	Refrigerator	IFE, Norway	Parcel post
100 ml brown glass	2	green	C-13, PMC	Refrigerator	Waterloo	Parcel post
1,000 ml	1	green	S-34	Refrigerator	IFE, Norway	Parcel post
100 ml quadrangular	1	green	U-, Th-isotopes	Refrigerator	IFE, Norway	Parcel post
500 ml PEH bottle		green	Ra-, Rn-isotopes	Refrigerator	IFE, Norway	DHL
250 ml	2	green	Archive	Freezer	–	–
100 ml	2	red	Archive	Freezer	–	–

During the year some changes of the methods used have occurred:

- From April 2004 samples for estimation of density were performed at all sites, as far as supply of water admitted.
- From week number 27, the vessels for analysis of Cl-37 and Tritium were separated in two different bottles.
- From week 36, new bottles for sampling in the field were introduced: Acid rinsed bottles for analysis of standard elements and iron (Fe II+Fe-tot) were used instead of collecting vessels. The bottle for analysis of Sulphide was flowed over in the field to minimise oxygen bubbles.
- From week 41 it was decided that when chemical programme class 3 was performed only deuterium, tritium and ¹⁸O were sampled as optional components (see Table 2-1).

4.3 Documentation

All activities were continuously documented. Notes were taken on field conditions, time of sampling, marking of samples and so forth. Any deviations from the normal routines were also noted and commented in a special report. Delivery notes with instructions on which components to analyse were always sent with the samples to the different laboratories.

After analysis data has continuously been reported from the laboratories. As a routine a first preliminary quality control of the data was performed before storing them in the database SICADA.

5 Nonconformities

It was not possible to sample the sites at all occasions. Three ground water wells in the Laxemar area (PSM000028, PSM000032 and PSM000033) were not possible to sample at all, and some other wells sometimes lacked water, which limited the number of components that could be analysed. In Table 5-1 and 5-2 some explanations are listed on why sampling could not be performed and why some components were not analysed. In Appendix 3 and 4 lists of sampled and analysed components at the different sites and sampling occasions are presented for each area.

Measuring water temperature in the field was not performed during 2004. Field measurements of pH were not performed in the Ävrö, Hälö and Simpevarp area during the sampling period in September.

During the end of 2004 there were some problems when analysing Bromide at Äspö Laboratory and some results in the database SICADA were excluded. When the Bromide values were above 0.2 mg/l and when Chloride values were above 100 mg/l the Bromide values were excluded. The results of Bromide values excluded were SSM000040 (SKB-number 7751), SSM000034 (SKB-number 7754), SSM000018 (SKB-number 7960 and SSM000022 (SKB-number 7962).

Table 5-1. Some components that could not be analysed in the Ävrö, Hälö and Simpevarp area 2004.

ID-code	Chemical class 3 week 13	Chemical class 5 week 24
SSM000016	Bottles for analysis of C-13 and PMC broken	
SSM000018		Bottles for analysis of C-13 and PMC broken
SSM000020	Concentration too low to run C-13	
SSM000026	Concentration too low to run C-13	Bottles for analysis of C-13 and PMC broken

Table 5-2. Sites that were not sampled, or were sampling in other ways deviated from the planned sampling schedule. The Laxemar area 2004.

ID-code	Chemical class 5 week 37–40	Chemical class 3 week 50–51
SSM000027	Concentration too low to run C-13	Frozen
SSM000028	No samples, lack of water	No samples, too high water level around the pipe
SSM000029		Frozen
SSM000030		Frozen
SSM000031	Concentration too low to run C-13	
SSM000032	No samples, lack of water	No samples, too high water level around the pipe
SSM000033	No samples, muddy water	No samples, the cover of the pipe was frozen
SSM000034		Frozen
SSM000035	Not all components analysed, lack of water	Frozen
SSM000037		Frozen
SSM000039		
SSM000040	Not all components analysed, lack of water Concentration too low to run C-13	
SSM000041	Not all components analysed, lack of water	Frozen
SSM000042	Not all components analysed, lack of water	

6 Results and discussion

6.1 Dissolved ions and conductivity

The concentrations of ions and the conductivity varied quite much between the sites in the different areas (Table 6-1 and 6-2). Most of the sites with the highest concentrations are situated close to the coast. The site SSM000042 which is situated quite far from the coast was an exception with comparably high concentrations of ions.

According to the Swedish Environmental Quality Criteria /Naturvårdsverket 1999/ the chloride concentrations range from low to high at different wells, with concentrations above 100 mg/l termed as high.

Table 6-1. Average concentration of major ions and conductivity in shallow ground water wells at Ävrö, Hålö and Simpevarp peninsula 2004. Figures in italic indicate that some individual values in the calculation were below the detection limit of the analysis.

Site number	Fe (mg/l)	Fe-tot (mg/l)	Fe ²⁺ (mg/l)	Na (mg/l)	K (mg/l)	Ca (mg/l)	Mg (mg/l)	Li (mg/l)
SSM000008	1.51	0.824	0.703	9.3	1.89	31.2	3.3	0.005
SSM000010	5.54	1.555	1.325	10.9	4.03	40.7	6.9	0.011
SSM000012	2.88	2.630	2.365	41.1	5.93	57.8	9.2	0.018
SSM000014	13.19	6.790	5.660	17.5	5.88	22.5	11.5	0.037
SSM000016	5.44	3.085	2.390	5.4	3.23	45.3	5.9	0.010
SSM000018	1.07	0.426	0.265	69.4	41.25	43.6	17.4	0.023
SSM000020	6.08	1.870	1.660	5.6	3.50	29.2	6.6	0.013
SSM000022	0.57	0.203	0.189	224.5	7.32	22.2	8.3	0.023
SSM000024	9.43	2.415	2.165	19.7	4.03	21.5	6.0	0.015
SSM000026	6.75	6.215	5.230	7.0	2.08	23.3	4.3	0.005
Site number	HCO ₃ (mg/l)	Cl (mg/l)	SO ₄ (mg/l)	SO ₄ -S (mg/l)	I (mg/l)	F (mg/l)	Sr (mg/l)	Conductivity (mS/m)
SSM000008	107.1	4.0	8.45	2.93	0.012	0.33	0.092	21.6
SSM000010	136.1	4.7	24.00	7.41	0.011	0.74	0.130	28.1
SSM000012	211.3	17.7	71.63	23.73	0.006	1.77	0.187	52.7
SSM000014	65.8	12.5	59.28	18.40	0.016	2.84	0.093	29.2
SSM000016	126.9	5.6	18.93	6.52	0.006	2.18	0.061	27.2
SSM000018	60.2	129.6	113.4	40.18	0.020	1.01	0.172	86.1
SSM000020	42.6	5.3	52.48	17.53	0.006	1.34	0.094	22.4
SSM000022	280.5	150.3	127.5	44.53	0.015	3.90	0.272	121.8
SSM000024	77.1	6.3	11.77	5.27	0.018	1.01	0.106	18.6
SSM000026	57.7	6.0	19.53	6.78	0.004	0.73	0.058	17.9

Table 6-2. Average concentration of major ions and conductivity in shallow ground water wells in the Laxemar area 2004. Figures in italic indicate that some individual values in the calculation were below the detection limit of the analysis.

Site number	Fe (mg/l)	Fe-tot (mg/l)	Fe ²⁺ (mg/l)	Na (mg/l)	K (mg/l)	Ca (mg/l)	Mg (mg/l)	Li (mg/l)
SSM000027	2.72	2.63	2.53	6.2	1.09	6.1	1.3	0.002
SSM000029	21.10	8.33	8.36	98.1	10.70	22.5	14.3	0.029
SSM000030	2.23	1.79	1.77	28.5	2.51	68.9	8.3	0.010
SSM000031	5.34	5.41	5.29	7.8	1.22	13.0	3.2	<i>0.004</i>
SSM000034	6.78	7.14	6.93	71.5	12.10	103.0	44.9	0.025
SSM000035								
SSM000037	12.30	5.81	4.92	34.3	5.71	55.4	10.8	0.031
SSM000039	12.70	1.78	1.49	10.2	3.63	26.0	6.0	<i>0.009</i>
SSM000040	19.60			74.2	9.72	26.5	19.9	0.019
SSM000041								
SSM000042	23.20			50.5	6.10	59.5	18.7	0.023

Site number	HCO ₃ (mg/l)	Cl (mg/l)	SO ₄ (mg/l)	SO ₄ -S (mg/l)	I (mg/l)	F (mg/l)	Sr (mg/l)	Conductivity (mS/m)
SSM000027	17.2	7.4	21.40	6.25	0.003	0.51	0.025	11.7
SSM000029	191.0	85.7	21.90	7.61	0.050	2.86	0.154	66.9
SSM000030	257.0	15.9	45.80	13.50	0.010	2.30	0.266	52.5
SSM000031	48.2	6.1	11.35	3.89	0.005	2.40	0.045	14.6
SSM000034	546.0	136.0	<i>0.20</i>	0.26	0.033	0.38	0.535	117.0
SSM000035	87.0							30.0
SSM000037	221.0	15.9	24.30	8.66	0.008	2.23	0.221	44.4
SSM000039	49.7	6.2	15.75	6.41	0.005	1.32	0.078	15.9
SSM000040	158.0	117.8	12.99	6.21		1.81	0.189	67.3
SSM000041	116.0							33.6
SSM000042	176.0	65.4	91.20	32.40		1.09	0.167	79.0

6.2 Density

The density of the water in different wells varied throughout the investigation areas (Table 6-3). To a great extent the variation is correlated to the concentration of ions and with the conductivity (Figure 6-1, Table 6-2 and Table 6-3). The result from one of the wells (SSM000030) deviates from the correlation with a density considerably higher than what is motivated by the conductivity.

6.3 Acidification

As with other ions the concentration of HCO₃ varied extensively throughout the investigation areas (Table 6-4). In most wells the concentration of HCO₃ was higher than 60 mg/l which is termed as a high concentration according to the Swedish Environmental Quality Criteria /Naturvårdsverket 1999/. In one well (SSM000027) the concentration of HCO₃ was lower than 30 mg/l which is termed as a low concentration according to the Swedish EQC. In this case the result is an indication of a problem with acidification in the ground water. The field measurements of pH were generally higher than the laboratory measurements. In most ground waters the opposite reaction is normal due to a shift in the carbonate system when the gas pressure in the water is equalised prior to the analysis in the laboratory. An explanation to the observed results might be high contents of inorganic manganese and iron which is oxidised when the water is aerated prior to the analysis.

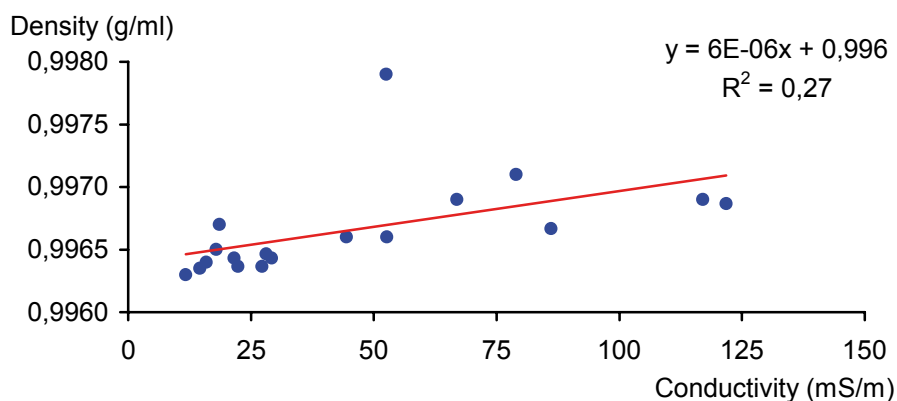


Figure 6-1. Relation of density and conductivity in ground water wells at Ävrö, Hålö, the Simpevarp peninsula and the Laxemar area 2004.

Table 6-3. Average density of water in shallow ground water wells at Ävrö, Hålö, the Simpevarp peninsula and the Laxemar area 2004.

Site number	Density (g/ml)	Site number	Density (g/ml)
SSM000008	0.9964	SSM000027	0.9963
SSM000010	0.9965	SSM000029	0.9969
SSM000012	0.9966	SSM000030	0.9979
SSM000014	0.9964	SSM000031	0.9964
SSM000016	0.9964	SSM000034	0.9969
SSM000018	0.9967	SSM000035	
SSM000020	0.9964	SSM000037	0.9966
SSM000022	0.9969	SSM000039	0.9964
SSM000024	0.9967	SSM000040	
SSM000026	0.9965	SSM000041	
		SSM000042	0.9971

Table 6-4. Average concentration of HCO₃, alkalinity and pH in shallow ground water wells at Ävrö, Hålö, the Simpevarp peninsula and the Laxemar area 2004.

Site number	HCO ₃ (mg/l)	Alkalinity (meq/l)	pH	pH-field	Site number	HCO ₃ (mg/l)	Alkalinity (meq/l)	pH	pH-field
SSM000008	107.1	1.76	6.78	6.75	SSM000027	17.2	0.28	5.82	6.40
SSM000010	136.1	2.23	6.91	6.93	SSM000029	191.0	3.13	6.67	7.09
SSM000012	211.3	3.46	7.51	7.94	SSM000030	257.0	4.21	7.19	7.76
SSM000014	65.8	1.08	6.34	6.61	SSM000031	48.2	0.79	6.39	6.65
SSM000016	126.9	2.08	6.55	6.90	SSM000034	546.0	8.95	6.92	7.49
SSM000018	60.2	0.99	6.19	6.68	SSM000035	87.0	1.43	6.71	7.33
SSM000020	42.6	0.70	6.20	6.39	SSM000037	221.0	3.62	6.94	7.55
SSM000022	280.5	4.60	7.89	8.05	SSM000039	49.7	0.81	6.25	6.54
SSM000024	77.1	1.26	6.67	6.68	SSM000040	158.0	2.59	6.76	7.01
SSM000026	57.7	0.95	6.39	6.51	SSM000041	116.0	1.90	6.60	
					SSM000042	176.0	2.89	6.84	

6.4 Environmental metals and trace elements

Measurements on environmental metals and trace elements were performed on samples from September 2004. The results are presented in Tables 6-5 to 6-8. The results varied quite much between the wells but there were strong relations between aluminium and most other elements, examples are shown in Figure 6-2. This indicates a good quality of the analysis performed.

Some of the environmental metals can be classified according to the Swedish Environmental Quality Criteria /Naturvårdsverket 1999/. According to these criteria's the concentration of As, Cd and Zn was low to moderately high in the different wells. These results are what to be expected in an unpolluted area. However, the concentration of Pb were high ($> 3 \mu\text{g/l}$) or very high ($> 10 \mu\text{g/l}$) in some of the wells. This could be an indication of some kind of pollution but since the relation to aluminium is similar to most other elements the high concentration of lead in some of the wells can probably be explained as a natural composition of the mineral in the Simpevarp area.

Table 6-5. Concentration of environmental metals in shallow ground water wells at Ävrö, Hälö and the Simpevarp peninsula 2004. Figures in italic indicate that some individual values in the calculation were below the detection limit of the analysis.

Site number	Al ($\mu\text{g/l}$)	As ($\mu\text{g/l}$)	Ba ($\mu\text{g/l}$)	Cd ($\mu\text{g/l}$)	Cr ($\mu\text{g/l}$)	Cu ($\mu\text{g/l}$)	Co ($\mu\text{g/l}$)
SSM000008	1,960	0.569	60.3	0.0444	4.01	11.2	1.36
SSM000010	1,970	0.611	61.8	0.007	3.38	8.41	1.76
SSM000012	1,140	0.490	49.3	<i>0.01</i>	1.99	1.84	0.824
SSM000014	3,600	1.26	63.4	0.0625	6.11	12.3	3.00
SSM000016	6,150	0.854	94.1	0.0506	17.8	19.2	4.71
SSM000018	2,020	0.631	101	0.117	4.00	13.5	3.80
SSM000020	1,380	0.58	53.7	0.0467	1.98	5.21	1.63
SSM000022	189	0.443	36.2	<i>0.03</i>	0.833	0.588	0.158
SSM000024	9,000	1.00	111	0.0835	16.0	22.5	7.48
SSM000026	1,960	1.33	38.9	<i>0.01</i>	3.75	4.72	1.40
Site number	Hg ($\mu\text{g/l}$)	Ni ($\mu\text{g/l}$)	Mo ($\mu\text{g/l}$)	Pb ($\mu\text{g/l}$)	V ($\mu\text{g/l}$)	Zn ($\mu\text{g/l}$)	
SSM000008	<i>0.002</i>	4.04	0.327	2.45	5.31	8.36	
SSM000010	<i>0.002</i>	3.46	0.615	2.54	5.33	10.2	
SSM000012	<i>0.002</i>	5.39	2.97	2.23	3.94	10.5	
SSM000014	<i>0.002</i>	7.44	2.21	17.2	10.8	20.8	
SSM000016	<i>0.002</i>	11.0	0.942	12.8	17.7	33.7	
SSM000018	<i>0.002</i>	13.8	1.42	2.48	5.07	16.2	
SSM000020	<i>0.002</i>	4.94	0.578	2.36	4.31	5.45	
SSM000022	<i>0.002</i>	0.791	13.8	0.234	1.15	2.19	
SSM000024	<i>0.002</i>	13.9	5.02	11.0	28.6	64.0	
SSM000026	<i>0.002</i>	3.73	0.904	2.27	7.14	10.6	

Table 6-6. Concentration of environmental metals in shallow ground water wells in the Laxemar area 2004. Figures in italic indicate that some individual values in the calculation were below the detection limit of the analysis.

Site number	Al (µg/l)	As (µg/l)	Ba (µg/l)	Cd (µg/l)	Cr (µg/l)	Cu (µg/l)	Co (µg/l)
SSM000027	476	0.652	25.9	0.0058	0.990	2.49	3.02
SSM000029		3.62	154	0.397	29.7	23.8	9.22
SSM000030	609	0.465	49.9	0.0129	1.95	2.17	0.692
SSM000031	1,700	0.264	25.3	0.0066	3.35	2.04	1.11
SSM000034	58.2	0.056	98.2	0.0023	0.690	0.164	0.0825
SSM000035							
SSM000037	5,750	0.948	107	0.0647	13.2	19.7	5.46
SSM000039	7,530	0.500	95.9	0.0698	9.85	24.1	5.46
SSM000040	3,450	1.92	67.7	0.133	11.6	11.3	2.30
SSM000041							
SSM000042							

Site number	Hg (µg/l)	Ni (µg/l)	Mo (µg/l)	Pb (µg/l)	V (µg/l)	Zn (µg/l)
SSM000027	<i>0.002</i>	3.15	0.741	0.607	2.66	15.7
SSM000029	<i>0.002</i>	20.4	0.570	29.0	54.5	70.8
SSM000030	<i>0.002</i>	2.49	1.45	1.53	8.37	14.9
SSM000031	<i>0.002</i>	1.85	0.336	3.68	12.5	10.4
SSM000034	<i>0.002</i>	0.38	0.0925	0.165	0.628	2.09
SSM000035						
SSM000037	<i>0.002</i>	10.7	2.69	21.1	23.9	41.1
SSM000039	<i>0.002</i>	9.16	0.603	23.6	24.2	48.5
SSM000040	<i>0.002</i>	6.93	1.37	8.87	19.5	27.9
SSM000041						
SSM000042						

Table 6-7. Concentration of trace elements in shallow ground water wells at Ävrö, Hålö and the Simpevarp peninsula 2004. Figures in italic indicate that some individual values in the calculation were below the detection limit of the analysis.

Site number	U (µg/l)	Th (µg/l)	Sc (µg/l)	Rb (µg/l)	Y (µg/l)	Zr (µg/l)	In (µg/l)	Sb (µg/l)	Cs (µg/l)
SSM000008	3.76	0.815	1.08	8.24	9.03	2.65	<i>0.050</i>	0.174	0.455
SSM000010	8.37	1.25	0.818	7.46	12.0	3.55	<i>0.050</i>	0.150	0.493
SSM000012	4.44	1.90	0.380	7.85	3.83	3.65	<i>0.050</i>	0.0695	0.266
SSM000014	11.8	2.17	0.970	14.8	7.78	4.49	<i>0.050</i>	0.110	0.847
SSM000016	7.99	3.78	1.90	26.9	14.2	4.31	<i>0.050</i>	0.216	1.91
SSM000018	2.15	0.752	0.432	40.7	8.37	2.37	<i>0.050</i>	0.344	0.378
SSM000020	1.90	0.833	0.503	7.54	12.9	1.99	<i>0.050</i>	0.109	0.210
SSM000022	9.56	0.191	0.0507	2.34	0.651	<i>0.300</i>	<i>0.050</i>	0.0931	0.065
SSM000024	6.02	7.90	3.05	34.4	35.5	9.90	<i>0.050</i>	0.201	2.61
SSM000026	1.22	1.17	0.700	9.12	9.91	3.95	<i>0.050</i>	0.129	0.433
Site number	La (µg/l)	Hf (µg/l)	Tl (µg/l)	Ce (µg/l)	Pr (µg/l)	Nd (µg/l)	Sm (µg/l)	Eu (µg/l)	
SSM000008	12.4	<i>0.050</i>	0.0637	23.0	2.72	10.7	1.89	0.346	
SSM000010	30.0	<i>0.050</i>	0.0641	23.9	5.08	18.7	2.92	0.425	
SSM000012	6.42	0.0507	0.0452	12.5	1.37	5.07	0.829	0.137	
SSM000014	16.3	0.0821	0.123	30.2	3.49	13.4	2.26	0.388	
SSM000016	30.9	0.0557	0.199	41.3	7.16	26.1	4.38	0.709	
SSM000018	13.2	<i>0.050</i>	0.0539	21.7	2.92	11.5	2.07	0.367	
SSM000020	22.1	<i>0.050</i>	0.0526	33.9	5.27	20.1	3.45	0.509	
SSM000022	0.818	<i>0.050</i>	<i>0.030</i>	1.13	0.182	0.688	0.116	0.0204	
SSM000024	47.1	0.284	0.248	105	19.1	67.5	10.2	1.56	
SSM000026	16.6	0.0721	0.0569	28.0	3.95	15.2	2.57	0.426	
Site number	Gd (µg/l)	Tb (µg/l)	Dy (µg/l)	Ho (µg/l)	Er (µg/l)	Tm (µg/l)	Yb (µg/l)	Lu (µg/l)	
SSM000008	1.90	0.267	1.36	0.267	0.768	0.106	0.702	0.115	
SSM000010	2.91	0.360	1.64	0.322	0.857	0.112	0.720	0.116	
SSM000012	0.799	0.113	0.565	0.114	0.340	0.0473	0.323	0.0535	
SSM000014	2.02	0.272	1.26	0.242	0.688	0.0943	0.644	0.103	
SSM000016	3.91	0.528	2.42	0.440	1.21	0.162	1.08	0.175	
SSM000018	2.03	0.259	1.26	0.245	0.684	0.0929	0.623	0.110	
SSM000020	3.30	0.414	1.95	0.387	1.01	0.139	0.905	0.144	
SSM000022	0.119	<i>0.050</i>	0.0823	0.0179	0.0497	0.0073	0.0428	0.0075	
SSM000024	9.70	1.22	5.47	1.01	2.61	0.347	2.18	0.318	
SSM000026	2.42	0.311	1.48	0.298	0.839	0.117	0.785	0.145	

Table 6-8. Concentration of trace elements in shallow ground water wells in the Laxemar area 2004. Figures in italic indicate that some individual values in the calculation were below the detection limit of the analysis.

Site number	U (µg/l)	Th (µg/l)	Sc (µg/l)	Rb (µg/l)	Y (µg/l)	Zr (µg/l)	In (µg/l)	Sb (µg/l)	Cs (µg/l)
SSM000027	0.650	0.405	0.197	3.40	4.08	0.401	<i>0.050</i>	0.0513	0.0843
SSM000029	9.15	6.27	3.98	45.2	42.5	6.70	<i>0.050</i>	0.0359	2.28
SSM000030	3.00	0.993	0.285	8.05	3.13	1.95	<i>0.050</i>	0.0363	0.747
SSM000031	1.89	2.30	0.831	7.28	11.3	3.04	<i>0.050</i>	0.0460	0.644
SSM000034	0.0237	0.0893	<i>0.050</i>	2.22	0.306	<i>0.300</i>	<i>0.050</i>	0.0200	<i>0.030</i>
SSM000035									
SSM000037	13.1	8.12	1.93	22.7	15.7	7.82	0.0698	0.208	3.40
SSM000039	13.5	8.08	2.69	24.6	43.7	7.07	<i>0.050</i>	0.220	3.45
SSM000040	10.3	1.78	1.13	17.3	14.5	6.76	<i>0.050</i>	0.192	0.936
SSM000041									
SSM000042									

Site number	La (µg/l)	Hf (µg/l)	Tl (µg/l)	Ce (µg/l)	Pr (µg/l)	Nd (µg/l)	Sm (µg/l)	Eu (µg/l)
SSM000027	7.46	<i>0.050</i>	<i>0.030</i>	14.8	1.71	6.57	1.09	0.175
SSM000029	55.4	0.209	0.312	142	17.4	63.3	10.5	1.61
SSM000030	6.47	<i>0.050</i>	0.0445	9.02	1.31	4.90	0.788	0.136
SSM000031	20.7	0.0681	0.0377	34.8	5.08	19.7	3.26	0.547
SSM000034	0.253	<i>0.050</i>	0.0431	0.464	0.0610	0.232	0.0391	0.0140
SSM000035								
SSM000037	49.5	0.172	0.163	82.1	9.39	33.1	4.91	0.816
SSM000039	96.4	0.127	0.199	152	26.4	98.7	14.5	2.32
SSM000040	29.5	0.162	0.097	41.8	5.38	20.9	3.40	0.579
SSM000041								
SSM000042								

Site number	Gd (µg/l)	Tb (µg/l)	Dy (µg/l)	Ho (µg/l)	Er (µg/l)	Tm (µg/l)	Yb (µg/l)	Lu (µg/l)
SSM000027	1.00	0.126	0.578	0.119	0.343	0.0503	0.361	0.0624
SSM000029	9.78	1.39	6.73	1.30	3.580	0.513	3.37	0.513
SSM000030	0.776	0.100	0.478	0.0926	0.258	0.0353	0.236	0.0368
SSM000031	2.97	0.376	1.64	0.321	0.855	0.116	0.753	0.120
SSM000034	0.0438	<i>0.050</i>	0.0328	0.0080	0.0258	<i>0.050</i>	0.0304	0.0058
SSM000035								
SSM000037	4.32	0.563	2.51	0.473	1.29	0.174	1.15	0.182
SSM000039	13.0	1.60	6.71	1.23	3.08	0.398	2.46	0.360
SSM000040	3.25	0.433	2.03	0.410	1.16	0.167	1.14	0.187
SSM000041								
SSM000042								

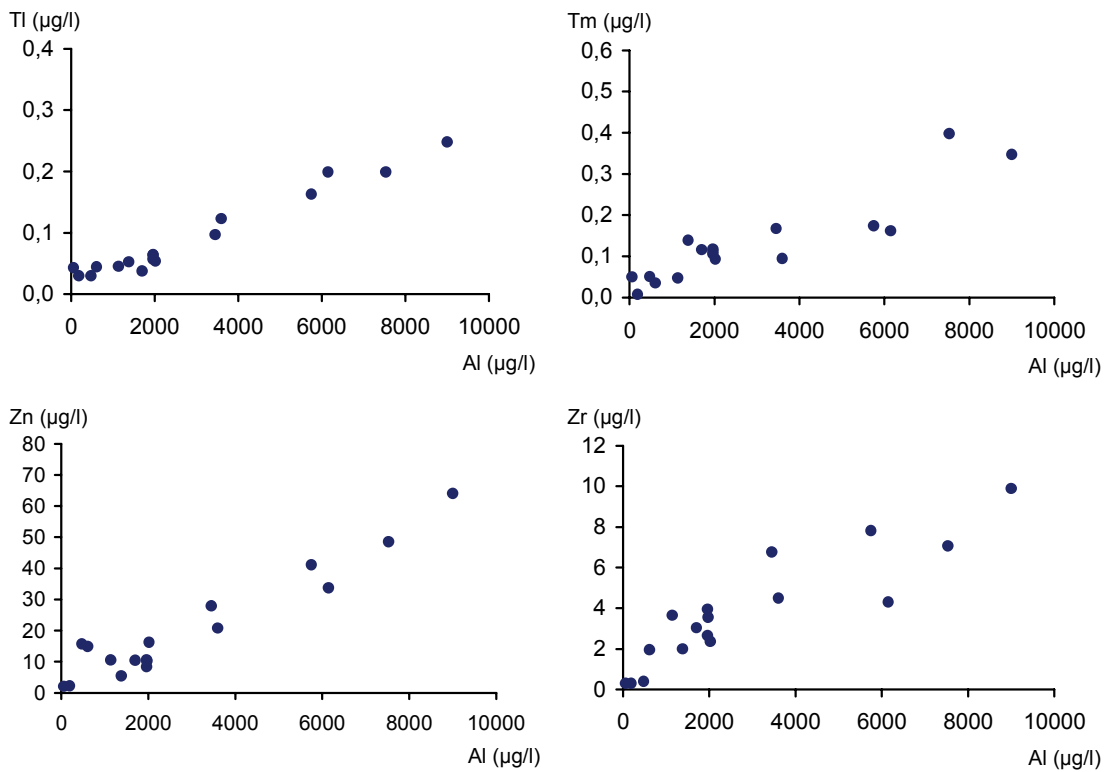


Figure 6-2. Relations between concentrations of Al and some other elements in ground water wells at Ävrö, Hälö, the Simpevarp peninsula and the Laxemar area 2004.

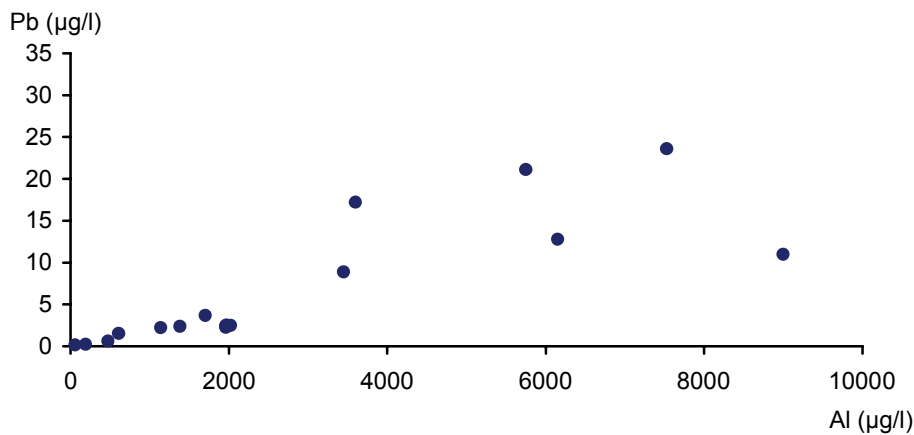


Figure 6-3. Relations between concentrations of Al and Pb in ground water wells at Ävrö, Hälö, the Simpevarp peninsula and the Laxemar area 2004.

6.5 Isotopes

The results of the measurements of isotopes are presented in Table 6-9 to Table 6-12. The average ratios of boron, chlorine, strontium and oxygen ($^{10}\text{B}/^{11}\text{B}$, ^{37}Cl , $^{87}\text{Sr}/^{86}\text{Sr}$ and ^{18}O) were similar in most wells and there seems to be low variation in the investigated areas. The isotopes of carbon and sulphur varied more between the different wells with the greatest variation in sulphur.

The average hydrogen isotope ratios of deuterium (D) and tritium (^3H) had similar values in most wells. However the well SSM000022 differed with a markedly lower ratio for tritium. The ratios of deuterium (dD) correlate well with the ratios of ^{18}O (Figure 6-4). The linear relation differs markedly from the "Global Meteoric Line" ($\text{dD} = 8 \times ^{18}\text{O} + 10$) which is based on precipitation data.

All measurements on thorium and of uranium-235 were below the reporting limits. The concentration of uranium-238 and uranium-234 was below or just over the reporting limit in most wells. The wells SSM000010, SSM000014 and SSM000022 differed with considerably higher concentrations for one or both of the uranium isotopes.

The concentration of radium was close to the reporting limit in the wells and there seems to be little variation in the investigation areas. The activity of radon varied to some extent but all values measured can (according to the Swedish Radiation Protection Authority) be considered as normal background values for shallow ground water /Swedish Radiation Protection Authority 2005/.

Table 6-9. Average ratio of isotopes in shallow ground water wells at Ävrö, Hålö and the Simpevarp peninsula 2004. Figures in italic indicate that some individual values in the calculation were below the detection limit of the analysis.

Site number	¹⁴ C (pmC)	¹³ C (‰ PDB)	d ³⁴ S (‰ CDT)	¹⁰ B/ ¹¹ B (atomic)	³⁷ Cl (‰ SMOC)	⁸⁷ Sr/ ⁸⁶ Sr (ratio)	dD (‰ VSMOW)	³ H (TU)	d ¹⁸ O (‰ VSMOW)
SSM000008	83.7	-17.3	0.8	0.2436	-0.32	0.7186	-76.4	13.4	-10.7
SSM000010	77.9	-17.5	-8.8	0.2445	-0.37	0.7189	-75.6	13.3	-10.5
SSM000012	66.1	-11.4	6.7	0.2406	0.12	0.7197	-75.2	10.5	-10.4
SSM000014	90.3	-18.2	-11.4	0.2432	0.19	0.7198	-73.8	13.7	-10.2
SSM000016	89.1	-17.9	-1.3	0.2417	-0.38	0.7333	-77.0	13.5	-10.5
SSM000018	97.6	-19.6	-2.3	0.2423	-0.26	0.7160	-75.2	12.4	-10.3
SSM000020	84.8	-18.8	-6.4	0.2468	-0.25	0.7224	-74.6	13.2	-10.2
SSM000022	45.5	-10.9	19.7	0.2367	-0.20	0.7159	-76.8	1.0	-10.4
SSM000024	94.0	-17.4	10.8	0.2401	-0.15	0.7211	-74.2	12.6	-10.1
SSM000026	88.0	-12.7	3.8	0.2429	-0.10	0.7232	-74.5	13.8	-10.1

Table 6-10. Average ratio of isotopes in shallow ground water wells in the Laxemar area 2004. Figures in italic indicate that some individual values in the calculation were below the detection limit of the analysis.

Site number	¹⁴ C (pmC)	¹³ C (‰ PDB)	d ³⁴ S (‰ CDT)	¹⁰ B/ ¹¹ B (atomic)	³⁷ Cl (‰ SMOC)	⁸⁷ Sr/ ⁸⁶ Sr (ratio)	dD (‰ VSMOW)	³ H (TU)	d ¹⁸ O (‰ VSMOW)
SSM000027			0.7	0.2465	-0.17	0.71861	-84.3	9.6	-11.3
SSM000029	86.1	-12.4	22.4	0.2417	0.11	0.71607	-80.4	11.0	-10.9
SSM000030	69.4	-15.2	11.0	0.2421	0.03	0.71494	-77.4	8.7	-10.9
SSM000031			5.1	0.2450	0.42	0.72017	-75.8	11.9	-10.6
SSM000034	105.0	-10.7		0.2451	-0.85	0.71169	-78.5	14.8	-10.9
SSM000035									
SSM000037	77.5	-14.6	17.0	0.2427	-0.06	0.71877	-77.4	10.7	-11.0
SSM000039	95.5	-12.4	-5.9	0.2452	-0.18	0.72198	-77.0	12.2	-10.6
SSM000040				0.2443		0.71397	-77.1	12.7	-10.7
SSM000041									
SSM000042							-75.8	8.7	-10.5

Table 6-11. Average concentration of radioactive isotopes in shallow ground water wells at Ävrö, Hälö and the Simpevarp peninsula 2004. Figures in italic indicate that some individual values in the calculation were below the detection limit of the analysis.

Site number	²²⁶ Ra (Bq/l)	²²² Rn (Bq/l)	²³⁸ U (mBq/kg)	²³⁵ U (mBq/kg)	²³⁴ U (mBq/kg)	²³² Th (mBq/kg)	²³⁰ Th (mBq/kg)
SSM000008	0.10	23.5	50	50	50	50	50
SSM000010	0.10	21.0	110	50	90	50	50
SSM000012	0.30	20.7	60	50	50	50	50
SSM000014	0.15	42.0	90	50	140	50	50
SSM000016	0.10	30.9	90	50	80	50	50
SSM000018	0.30	24.7	50	50	50	50	50
SSM000020	0.15	23.1	50	50	50	50	50
SSM000022	0.10	16.6	130	50	240	50	50
SSM000024	0.10	12.6	50	50	50	50	50
SSM000026	0.10	21.9	50	50	50	50	50

Table 6-12. Average concentration of radioactive isotopes in shallow ground water wells in the Laxemar area 2004. Figures in italic indicate that some individual values in the calculation were below the detection limit of the analysis.

Site number	²²⁶ Ra (Bq/l)	²²² Rn (Bq/l)	²³⁸ U (mBq/kg)	²³⁵ U (mBq/kg)	²³⁴ U (mBq/kg)	²³² Th (mBq/kg)	²³⁰ Th (mBq/kg)
SSM000027	0.20	11.0	50	50	50	50	50
SSM000029	0.20	13.3	50	50	80	50	50
SSM000030	0.10	12.5	50	50	80	50	50
SSM000031	0.20	38.1	50	50	50	50	50
SSM000034	0.10	17.0	50	50	50	50	50
SSM000035							
SSM000037	0.10	14.9	50	50	50	50	50
SSM000039	0.20	30.2	50	50	80	50	50
SSM000040							
SSM000041							
SSM000042							

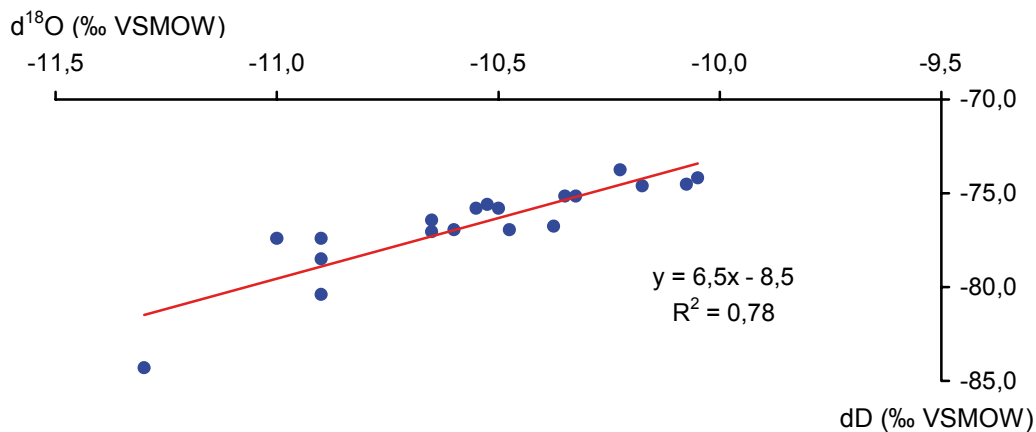


Figure 6-4. The relationship between the ratios of deuterium (dD) and ¹⁸O in ground water wells at Ävrö, Hälö, the Simpevarp peninsula and the Laxemar area 2004.

6.6 Other substances

The concentration of nitrate varied with considerable higher concentration in some of the wells (Table 6-13 and Table 6-14). However, according to the Swedish Environmental Quality Criteria /Naturvårdsverket 1999/ the concentration in all wells was very low. Likewise the concentration of phosphorus, silica and sulphur varied with considerably higher values in some of the wells. Since these results are from single measurements in the wells the variation between the wells might prove different when more sampling occasions are taken into consideration. The concentration of carbon varied with values up to 19 mg/l in one of the wells. This is only slightly lower than most surface waters in the area /Ericsson and Engdahl 2004/.

Table 6-13. Concentration of nitrogen and phosphorus compounds, silica, sulphur and carbon in shallow ground water wells at Ävrö, Hålö and Simpevarp peninsula 2004. The values on NH₄-N and sulphide are averages from two measurements. Figures in italic indicate that some individual values in the calculation were below the detection limit of the analysis.

Site number	NO ₂ -N (mg/l)	NO ₃ -N (mg/l)	NO ₂ /NO ₃ -N (mg/l)	NH ₄ -N (mg/l)	PO ₄ -P (mg/l)	P (mg/l)	Si (mg/l)	Sulphide (mg/l)	SO ₄ (mg/l)	S (mg/l)	TOC (mg/l)	DOC (mg/l)
SSM000008	0.0002	0.0014	0.0016	0.0237	<i>0.0005</i>	0.0552	7.92	0.005	8.45	2.93	16.0	15.0
SSM000010	0.0006	0.0054	0.0060	0.0305	<i>0.0005</i>	0.0567	12.28	0.005	24.00	7.41	14.0	15.0
SSM000012	0.0001	0.0007	0.0007	0.1580	<i>0.0005</i>	0.0613	8.84	0.014	71.63	23.73	8.2	8.3
SSM000014	0.0002	0.0007	0.0009	0.0993	<i>0.0005</i>	0.1040	17.98	0.006	59.28	18.40	7.6	7.4
SSM000016	0.0002	0.2140	0.2140	0.0033	<i>0.0005</i>	0.2490	10.98	<i>0.005</i>	18.93	6.52	6.8	6.5
SSM000018	0.0014	0.0438	0.0452	0.0358	0.0070	0.0917	12.25	0.010	113.43	40.18	10.0	9.4
SSM000020	0.0002	0.0032	0.0034	0.0232	<i>0.0005</i>	0.0259	12.65	0.007	52.48	17.53	14.0	12.0
SSM000022	0.0007	0.0004	0.0010	0.6345	0.0056	0.0305	5.20	0.039	127.50	44.53	5.2	5.3
SSM000024	0.0003	0.0006	0.0009	0.0252	0.0026	0.4290	16.68	0.016	11.77	5.27	18.0	19.0
SSM000026	0.0007	0.0057	0.0064	0.1260	<i>0.0005</i>	0.0879	10.51	0.012	19.53	6.78	14.0	13.0

Table 6-14. Concentration of nitrogen and phosphorus compounds, silica, sulphur and carbon in shallow ground water wells in the Laxemar area 2004. Figures in italic indicate that some individual values in the calculation were below the detection limit of the analysis.

Site number	NO ₂ -N (mg/l)	NO ₃ -N (mg/l)	NO ₂ /NO ₃ -N (mg/l)	NH ₄ -N (mg/l)	PO ₄ -P (mg/l)	P (mg/l)	Si (mg/l)	Sulphide (mg/l)	SO ₄ (mg/l)	S (mg/l)	TOC (mg/l)	DOC (mg/l)
SSM000027	0.0003	0.2140	0.2140	0.0644	<i>0.0005</i>	0.0269	8.29	0.003	21.40	6.25	3.3	3.9
SSM000029	0.0004	0.0005	0.0009	0.6140	0.0014	0.5700	25.60	0.015	21.90	7.61	11.0	11.0
SSM000030	0.0001	0.0033	0.0033	1.6100	0.0011	0.1760	9.03	0.011	45.80	13.50	8.4	8.3
SSM000031	0.0003	<i>0.0002</i>	0.0004	0.0442	<i>0.0005</i>	0.0768	9.40	0.007	11.35	3.89	8.5	8.2
SSM000034	0.0003	0.0009	0.0012	0.2580	<i>0.0005</i>	0.1200	13.20	0.036	<i>0.20</i>	0.26	7.5	7.0
SSM000035												
SSM000037	0.0002	0.0002	0.0004	0.2210	<i>0.0005</i>	0.4720	20.20	0.005	24.30	8.66	6.1	6.4
SSM000039	0.0015	0.1330	0.1340	0.0075	<i>0.0005</i>	0.4300	18.75	0.007	15.75	6.41	5.2	5.1
SSM000040							17.95		12.99	6.21		
SSM000041												
SSM000042							32.50		91.20	32.40		

7 References

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Sites, co-ordinates and sampling depths

Sites, sample depths and location co-ordinates at the Ävrö, Hålö and Simpevarp area 2004.

ID-code	Co-ordinate X	Co-ordinate Y	Sampling depth (m)
SSM000008	6365431	1550751	3–5
SSM000010	6365447	1550748	2–3
SSM000012	6366645	1552435	5–6
SSM000014	6366286	1550813	2–3
SSM000016	6367372	1552222	2–3
SSM000018	6367038	1552192	2–3
SSM000020	6367186	1552743	2–3
SSM000022	6367458	1553120	5–7
SSM000024	6366790	1553084	1.8–3.8
SSM000026	6366715	1552749	2–4

Sites, sample depths and location co-ordinates at the Laxemar area 2004.

ID-code	Co-ordinate X	Co-ordinate Y	Sampling depth (m)
SSM000027	6370909	1544779	3–5
SSM000028	6369643	1546933	–
SSM000029	6368976	1548879	5–7
SSM000030	6367908	1546986	4–5
SSM000031	6368133	1548563	3–4
SSM000032	6367971	1549397	–
SSM000033	6368095	1549884	–
SSM000034	6368090	1550123	3–4
SSM000035	6365138	1540387	3–4
SSM000037	6367186	1547490	3–4
SSM000039	6366620	1549136	3–5
SSM000040	6366207	1550351	2–3
SSM000041	6365332	1548655	2–4
SSM000042	6365541	1549488	3–5

Schedule – sampling of shallow ground water at Simpevarp 2004

Sampling occasions and programmes at the Ävrö, Hålö and Simpevarp area 2004.

Month Programme	March Week number	June	September	December
Chemical class 3	13			51
Chemical class 5		24	37	

Sampling occasions and programmes at the Laxemar area 2004.

Month Programme	March Week number	June	September	December
Chemical class 3				50–51
Chemical class 5			37–40	

Components sampled and analysed at the different sites and sampling occasions at the Ävrö, Hålö and Simpevarp area 2004

ID-code	Chemical class 3 week 13	Chemical class 5 week 24
SSM000008	Complete	Reduced to class 3. Ra and Rd, but not B-10.
SSM000010	Complete	Reduced to class 3. Ra and Rd, but not B-10.
SSM000012	Complete	Reduced to class 3. Ra and Rd, but not B-10.
SSM000014	Complete	Reduced to class 3. Ra and Rd, but not B-10.
SSM000016	Complete, except for C-13 and PMC	Reduced to class 3. Ra and Rd, but not B-10.
SSM000018	Complete	Reduced to class 3. Ra and Rd, but not B-10, C-13 and PMC.
SSM000020	Complete	Reduced to class 3. Ra and Rd, but not B-10.
SSM000022	Complete	Reduced to class 3. Ra and Rd, but not B-10.
SSM000024	Complete	Reduced to class 3. Ra and Rd, but not B-10.
SSM000026	Complete	Reduced to class 3. Ra and Rd, but not B-10, C-13 and PMC.

ID-code	Chemical class 5 week 37	Chemical class 3 week 51
SSM000008	Complete	alk/pH/cond, anions, kations, deuterium, O-18, Tritium, density.
SSM000010	Complete	alk/pH/cond, anions, kations, deuterium, O-18, Tritium, density.
SSM000012	Complete	alk/pH/cond, anions, kations, deuterium, O-18, Tritium, density.
SSM000014	Complete	alk/pH/cond, anions, kations, deuterium, O-18, Tritium, density.
SSM000016	Complete	alk/pH/cond, anions, kations, deuterium, O-18, Tritium, density.
SSM000018	Complete	alk/pH/cond, anions, kations, deuterium, O-18, Tritium, density.
SSM000020	Complete	alk/pH/cond, anions, kations, deuterium, O-18, Tritium, density.
SSM000022	Complete	alk/pH/cond, anions, kations, deuterium, O-18, Tritium, density.
SSM000024	Complete	alk/pH/cond, anions, kations, deuterium, O-18, Tritium, density.
SSM000026	Complete	alk/pH/cond, anions, kations, deuterium, O-18, Tritium, density.

Components sampled and analysed at the different sites and sampling occasions at the Laxemar area 2004

ID-code	Chemical class 5 week 37–40	Chemical class 3 week 50–51
SSM000027	Complete, except for C-13 and PMC	No samples
SSM000028	No samples	No samples
SSM000029	Complete	No samples
SSM000030	Complete	No samples
SSM000031	Complete, except for C-13 and PMC	Alkalinity, pH, conductivity, anions, kations, deuterium, tritium, O-18, density.
SSM000032	No samples	No samples
SSM000033	No samples	No samples
SSM000034	Complete, except for S-34	No samples
SSM000035	Alkalinity, pH, conductivity	No samples
SSM000037	Complete	No samples
SSM000039	Complete	Alkalinity, pH, conductivity, anions, kations, deuterium, tritium, O-18, density.
SSM000040	Alkalinity, pH, conductivity, anions, kations, environmental metals, trace elements, lantanoides, B-10, In, As, Sr-87, deuterium, tritium, O-18	Alkalinity, pH, conductivity, anions, kations, deuterium, tritium, O-18, density.
SSM000041	Alkalinity, pH, conductivity	No samples
SSM000042	Alkalinity, pH, conductivity	Alkalinity, pH, conductivity, anions, kations, deuterium, tritium, O-18, density.