Project: “Monitoring Sea-water intrusion in coastal aquifers and Testing pilot projects for its mitigation” Interreg CBC Italy-Croatia 2014.-2020.

Priority Axis: Safety and resilience

Specific objective: Improve the climate change monitoring and planning of adaptation measures tackling specific effects, in the cooperation area

(D_3.2.7) Report on the water quality on samples collected in the Croatian site

Work Package 3: Studying

Activity 2: Laboratory investigations

Partner in charge: PP4 (UNIST-FGAG)

Partners involved: PP4 (UNIST-FGAG), PP5 (CROATIAN WATERS), PP6 (DUNEA)

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Contents

Aims and scopes

The plan is made to define the content of the monitoring activities to be done on Croatian project site river Neretva delta as an activity proposed by the project: “Monitoring Sea-water intrusion in coastal aquifers and Testing pilot projects for its mitigation” Interreg CBC Italy-Croatia 2014.-2020.

As a part of monitoring activities, the sampling of the ground water and surface water for purpose of laboratory analysis of the samples as taken from the area of interest at Croatian site is implemented. Four sets of surface and ground water samples have been taken and analyzed. The results of laboratory analysis are shown in this report.

Plan of ground and surface water samplings

To support real time monitoring data series with additional data in order to enable the understanding of processes influencing salt water dynamic nature, in total 124 water samples were taken from study area within one hydrological year. These samples, once taken in situ, were transported to laboratory to conduct laboratory analysis. Following Figure 1 in total 31 locations have been selected for water sampling, 24 of them representing surface water samples and 7 of them representing ground water samples. Groundwater samples were planned to be taken by existing piezometers, while surface water was taken directly from surface channels at 30 cm upward from the channel bottom. Ground water samples were taken from piezometers at the depth which was defined in addition to present state found at the piezometers prior the sample is taken.

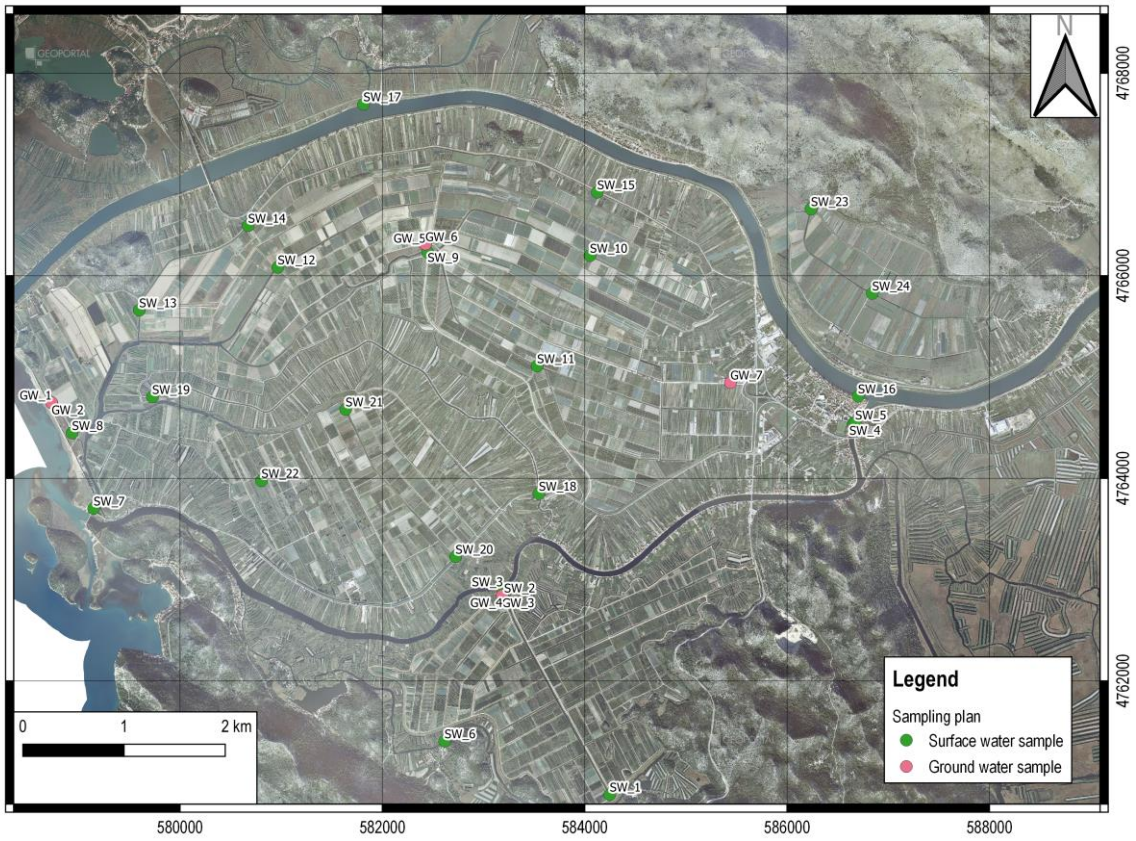

Figure 1 Locations for in-situ water samples to be taken

Specifications of coordinates of monitoring locations have been identified and shown in Table 1 while locations of ground and surface water sampling points have been shown separately in Figure 2 and Figure 3

Table 1 Coordinates of the water sampling locations within the study area

Sample ID	E (HTRS96)	N (HTRS96)
SW_1	584247.54	4760878.80
SW_2	583204.08	4762862.23
SW_3	583190.57	4762905.25
SW_4	586654.09	4764542.97
SW_5	586673.94	4764552.64
SW_6	582614.39	4761405.10
SW_7	579146.50	4763702.34
SW_8	578932.86	4764448.00
SW_9	582447.09	4766232.52
SW_10	584051.36	4766198.65
SW_11	583529.52	4765108.22
SW_12	580965.86	4766083.72
SW_13	579596.95	4765659.56
SW_14	580673.15	4766494.48
SW_15	584123.94	4766824.63
SW_16	586701.34	4764810.66
SW_17	581812.59	4767693.12
SW_18	583546.75	4763849.08
SW_19	579725.98	4764803.49
SW_20	582723.05	4763226.34
SW_21	581636.78	4764681.08
SW_22	580805.19	4763975.95
SW_23	586236.35	4766659.11
SW_24	586841.52	4765825.75
GW_2	578731.46	4764745.82
GW_1	578730.63	4764748.10
GW_3	583185.45	4762841.51
GW_4	583184.67	4762843.02
GW_5	582425.97	4766315.43
GW_6	582426.03	4766312.78
GW_7	585440.35	4764946.47

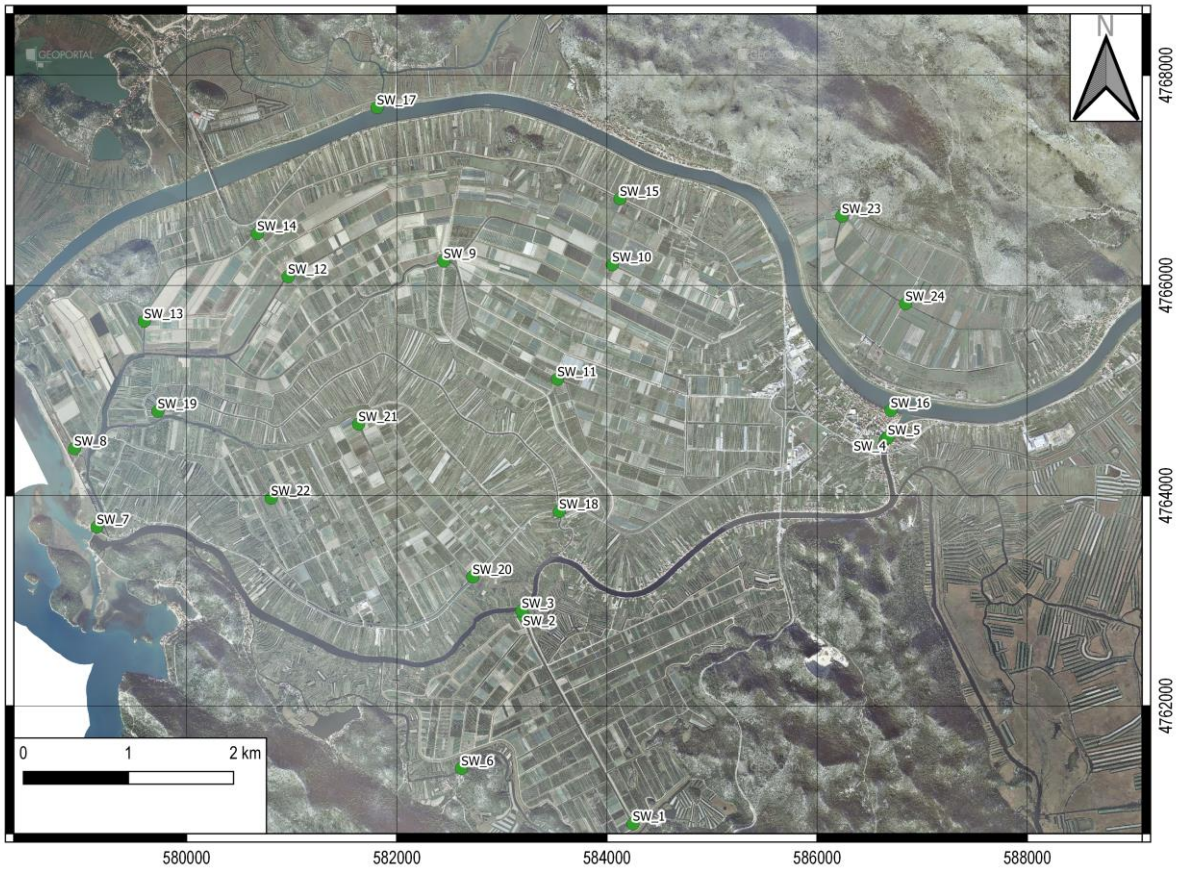

Figure 2 Locations for in-situ surface water samples to be taken

Samples of surface and ground water were taken four times during hydrological year, two times during wet (rain) and two times during dry period (season). Water sampling needed to be done with a specially designed sampler with a minimum sampling capacity of 500 ml. After sampling was done, water samples were packed in PE bottles and transported to the laboratory for further analyses.

Figure 3 Location for in-situ ground water samples to be taken

For every surface and groundwater sample values of pH, total dissolved solids (TDS, mg/L) and electrical conductivity (EC, µS/cm) were determined. The values of the following compounds and chemical elements were also determined: CO_3 + HCO_3, Cl^-, SO_4^{2-}, Ca, Mg, Na, K, nitrates, nitrites, ammonia and orthophosphates. Units for all elements are mg/L.

Sample analyzes were performed:

- 26th, 27th and 28th of May 2021 - first group of samples
- 30th of June, 1st and 2nd of July 2021 - second group of samples
- 10th, 11th and 12th of November 2021 - third group of samples
- 16th, 17th and 20th of December 2021 - fourth group of samples.

pH, conductivity (EC) and total dissolved substances (TDS)

The pH, conductivity (EC) and total dissolved substances (TDS) values of samples were determined with a HACH Sension156 portable multimeter (Figure 4) previously calibrated with certified Lachner pH 4 and 7 standards and for Hanna instruments 1413 µS / cm.

Figure 4 Multimetar Sension156, HACH

Elements K^+, Na^+, Ca^{2+} and Mg^{2+}

Water samples were filtered through a 0.45 µm pore filter. They were then analyzed on a PerkinElmer Atomic Absorption Spectrometer AAnalyst 800, Figure 5. Flame technique (FAAS) was used to analyze elements K^+, Na^+, Ca^{2+} and Mg^{2+}. Compressed air as an oxidant and acetylene 2.6 as a carrier gas were used for the flame technique. Appropriate HCL lamps were used as radiation sources of known wavelength for the elements Ca^{2+} and Mg^{2+}.
Standard (working) solutions of known concentrations required for calibration were made from certified reference standards Inorganic Ventures with a concentration of 1000 µg/mL which were diluted to the desired concentration with ultrapure water (type 1). These standard solutions were used to create calibration curves according to which unknown concentrations of elements in the samples were determined.

Figure 5 Atomic absorption spectrometer AAnalyst 800, PerkinElmer

Chloride

Two reagents, 1ml of Mercuric Thiocyanate Solution and 0,5 ml of Ferric Ion Solution, are added to 10 ml of sample. Deionized water is used as blank. Chlorides in the sample reacts with mercuric thiocyanate to form mercuric chloride. Free thiocyanate ions react with the ferric ions to form an orange ferric thiocyanate complex. The amount of this complex is proportional to the chloride concentration. The results are measured at 455 nm.

Nitrates

A sample cell is filled with 10 mL of sample and contents of one NitraVer5 powder pillow is added to the sample. Another sample cell is filled with clear sample and used as a blank. Cadmium metal reduces nitrate in the sample to nitrite. The nitrite ions react in an acidic medium with sulfanilic acid to form an intermediate diazonium salt. The salt couples with chromotropic acid to form a pink-coloured complex. The measurement wavelength is 507 nm.

Nitrites

A sample cell is filled with 10 mL of sample and contents of one NitriVer 3 powder pillow is added to the sample. Another sample cell is filled with clear sample and used as a blank. Nitrite in the sample reacts with sulfanilic acid to form an intermediate diazonium salt. This couples with chromotropic acid to produce a pink-coloured complex directly proportional to the amount of nitrite present. The results are measured at 507 nm.

Sulphate

A sample cell is filled with 10 mL of sample and contents of one SulfaVer4 powder pillow is added to the sample. Another sample cell is filled with clear sample and used as a blank. Sulphate ions in the sample react with barium in the SulfaVer 4 and form barium sulphate. The amount of turbidity is proportional to the sulphate concentration. The measurement wavelength is 450 nm.

Ammonia

A sample cell is filled with 10 mL of sample and contents of two reagents, Ammonia salicylate and Ammonia cyanurate, are added to the sample. Another sample cell is filled with deionized water and used as a blank. Ammonia compounds combine with chlorine to form monochloramine. Monochloramine reacts with salicylate to form 5-aminosalicylate. The 5-aminosalicylate is oxidized in the presence of a sodium nitroprusside catalyst to form a blue-coloured complex. The blue colour is hidden by the yellow colour from the excess reagent to give a final, green-coloured solution. The measurement wavelength is 655 nm.

Orthophosphates

A sample cell is filled with 10 mL of sample and contents of one PhosVer4 powder pillow is added to the sample. Another sample cell is filled with clear sample and used as a blank. In a highly acidic solution, ammonium molybdate reacts with orthophosphate to form molybdophosphoric acid. This complex is then reduced by the amino acid reagent to yield an intensely coloured molybdenum blue compound. The measurement wavelength is 530 nm.
Chloride, nitrates, nitrites, sulphate, ammonia and orthophosphates were determined on spectrophotometer Hach Lange DR500, Figure 6.

Figure 6 Spectrophotometer Hach Lange DR500

Alkalinity

The term 'alkalinity' is usually used to describe to total alkalinity (T alkalinity) or methylorange alkalinity, otherwise known as M alkalinity. In an Erlenmeyer flask a 100ml of sample was added together with 3 drops of methylorange indicator. The sample was titrated with 0,1 M HCl until the change in colour, Figure 7.

Figure 7 Determination of alkalinity by titration

Results of the first group of samples

Table 2 Values of pH, TDS and EC for first group of ground and surface samples

SAMPLE	pH	TDS (mg/L)	EC (µS/cm)
SW 1	7.81	477	953
SW 2	7.59	2300	4600
SW 3	7.89	848	1697
SW 4	8.20	519	1038
SW 5	8.00	1499	3000
SW 6	7.52	1152	2300
SW 7	7.75	1395	2790
SW 8	7.76	9220	18430
SW 9	7.83	793	1586
SW 10	7.54	1535	3070
SW 11	8.00	721	1442
SW 12	7.47	1974	3950
SW 13	7.38	2710	5410
SW 14	7.34	3190	6390
SW 15	7.43	1669	3340
SW 16	7.95	1325	2650
SW 17	7.94	7230	14460
SW 18	7.99	480	959
SW 19	7.98	475	951
SW 20	7.68	566	1133
SW 21	7.65	630	1260
SW 22	7.48	1313	2630
SW 23	7.46	5710	11430
SW 24	7.60	6520	13050
GW 1	7.32	28700	57500
GW 2 0,5m	7.48	23300	46700
GW 2 5,0m	7.47	24500	48900
GW 3	7.59	11150	22300
GW 4 0,5m	7.11	1345	2690
GW 4 5,0m	7.14	1187	2370
GW 5 0,5	7.15	9180	18350
GW 5 5,0	6.91	16750	33500
GW 6	7.69	17470	34900
GW 7	7.57	21900	43800

Table 3 Values of CO3 + HCO3, Cl-, SO42-, Ca, Mg, Na, K for first group of ground and surface samples

SAMPLE	$CO_3 + HCO_3$	Cl- (mg/L)	SO_4^{2-} (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)
SW 1	250.00	4500.00	350.00	144.5	302.0	2396.0	88.0
SW 2	255.00	800.00	145.00	102.2	148.0	878.0	199.9
SW 3	190.00	1200.00	62.00	48.6	34.5	416.0	93.8
SW 4	155.00	900.00	45.00	16.5	21.7	668.0	20.4
SW 5	175.00	1700.00	66.00	42.7	58.2	596.0	42.7
SW 6	210.00	1400.00	66.00	21.9	34.2	442.0	17.8
SW 7	205.00	1700.00	108.00	42.7	53.9	624.0	36.1
SW 8	90.00	8900.00	650.00	142.0	447.0	3260.0	170.9
SW 9	185.00	1200.00	78.00	18.7	32.3	668.0	39.3
SW 10	200.00	1700.00	130.00	32.3	108.0	586.0	42.8
SW 11	185.00	1100.00	70.00	15.9	28.6	598.0	32.0
SW 12	215.00	2000.00	134.00	43.2	123.0	790.0	47.9
SW 13	215.00	2800.00	215.00	55.6	155.0	1092.0	59.1
SW 14	285.00	3100.00	235.00	68.0	175.0	1210.0	69.6
SW 15	180.00	1800.00	128.00	37.8	114.0	778.0	30.7
SW 16	170.00	1400.00	110.00	28.2	50.3	572.0	34.7
SW 17	190.00	6500.00	540.00	109.4	363.0	3034.0	148.5
SW 18	172.50	800.00	36.00	13.9	20.8	410.0	9.1
SW 19	167.50	400.00	44.00	11.5	19.6	308.0	9.3
SW 20	185.00	800.00	46.00	12.5	22.3	358.0	18.6
SW 21	187.50	900.00	56.00	11.9	25.0	406.0	9.7
SW 22	295.00	1100.00	124.00	70.7	51.2	600.0	36.5
SW 23	250.00	2800.00	345.00	140.4	272.0	1924.0	108.4
SW 24	280.00	3400.00	550.00	153.9	315.0	2364.0	116.5
GW 1	100.00	16700.00	2600.00	829.0	1775.0	19460.0	662.0
GW 2 0,5m	205.00	25700.00	200.00	263.1	3015.0	15320.0	649.0
GW 2 5,0m	242.50	11700.00	1900.00	290.4	1745.0	10590.0	764.0
GW 3	507.50	5200.00	360.00	36.2	513.0	7495.0	417.0
GW 4 0,5m	520.00	7300.00	118.00	93.9	125.0	2664.0	27.9
GW 4 5,0m	495.00	900.00	106.00	94.0	116.0	1110.0	64.0
GW 5 0,5	1150.00	7600.00	410.00	42.3	296.0	3746.0	187.4
GW 5 5,0	1750.00	6900.00	170.00	81.9	686.0	8870.0	496.0
GW 6	145.00	14300.00	500.00	148.6	434.0	9630.0	535.0
GW 7	45.00	1400.00	2200.00	636.4	948.0	11280.0	573.0

Table 4 Values of nitrates, nitrites, ammonia and orthophosphates for first group of ground and surface samples

SAMPLE	nitrates (mg/L)	nitrites (mg/L)	ammonia (mg/L)	orthophosphates (mg/L)
SW 1	1.40	0.023	0.15	0.23
SW 2	1.20	0.033	0.16	9.20
SW 3	1.00	0.019	< DL	6.20
SW 4	1.00	0.012	< DL	5.60
SW 5	1.00	0.011	< DL	6.00
SW 6	1.00	0.021	9.50	1.48
SW 7	0.80	0.014	0.10	0.15
SW 8	3.10	0.170	0.40	0.40
SW 9	1.00	0.014	0.43	3.54
SW 10	1.60	0.025	< DL	0.14
SW 11	1.70	0.029	< DL	0.14
SW 12	1.50	0.021	0.01	0.62
SW 13	1.30	0.077	0.58	0.17
SW 14	2.20	0.033	3.50	0.60
SW 15	0.90	0.009	0.00	0.05
SW 16	1.10	0.016	< DL	0.07
SW 17	0.30	0.020	< DL	0.10
SW 18	1.30	0.015	< DL	0.43
SW 19	1.30	0.017	< DL	1.12
SW 20	1.30	0.013	< DL	3.15
SW 21	1.50	0.024	< DL	0.11
SW 22	1.30	< DL	< DL	0.78
SW 23	3.80	0.007	< DL	0.36
SW 24	2.80	0.019	< DL	0.12
GW 1	11.90	0.415	0.09	0.92
GW 2 0,5m	10.10	0.583	0.40	0.67
GW 2 5,0m	4.10	0.024	2.50	1.00
GW 3	12.00	0.082	40.00	0.63
GW 4 0,5m	1.50	0.022	3.50	0.49
GW 4 5,0m	1.80	0.045	2.50	0.56
GW 5 0,5	24.80	0.036	30.00	0.45
GW 5 5,0	35.50	0.032	120.00	3.70
GW 6	10.40	0.024	70.00	0.25
GW 7	20.10	0.013	20.00	< DL

Table 5 Statistics of the first group of samples

SAMPLE	SW 1	SW 8	SW 17	SW 22	SW 24	GW 2 0,5	GW 5 0,5	GW 6
pH	7.81	7.76	7.94	7.48	7.60	7.48	7.15	7.69
pH	7.81	7.76	7.94	7.48	7.60	7.48	7.15	7.69
pH	7.81	7.76	7.94	7.48	7.60	7.48	7.15	7.69
TDS (mg/L)	477	9220	7230	1313	6520	24500	9180	17470
TDS (mg/L)	477	9220	7230	1313	6520	24500	9180	17470
TDS (mg/L)	477	9220	7230	1313	6520	24500	9180	17470
EC (µS/cm)	953	18430	14460	2630	13050	46700	18350	34900
EC (µS/cm)	953	18430	14460	2630	13050	46700	18350	34900
EC (µS/cm)	953	18430	14460	2630	13050	46700	18350	34900
$CO_3 + HCO_3$	250	180	190	195	280	205	1150	290
$CO_3 + HCO_3$	250	210	180	275	270	205	1170	280
$CO_3 + HCO_3$	245	220	170	185	280	200	1150	285
Cl- (mg/L)	4500	8900	6500	1100	3400	25700	7200	14300
Cl- (mg/L)	4600	8900	6500	1300	5300	21700	7500	15300
Cl- (mg/L)	4400	9700	6200	1300	5600	21600	8100	17600
SO_4^{2-} (mg/L)	350	650	540	124	550	1200	410	500
SO_4^{2-} (mg/L)	350	660	550	122	560	140	430	490
SO_4^{2-} (mg/L)	345	660	540	124	550	800	420	480
Ca (mg/L)	144.5	141.8	111.4	69.7	153.5	259.3	43.1	146.3
Ca (mg/L)	143.4	142.6	108.6	70.4	152.6	263.8	42.4	150.5
Ca (mg/L)	145.8	141.5	108.4	71.9	155.6	266.3	41.5	149.1
Mg (mg/L)	303.0	444.0	362.0	50.8	313.0	3025.0	293.0	437.0
Mg (mg/L)	301.0	448.0	366.0	51.4	320.0	3020.0	297.0	433.0
Mg (mg/L)	301.0	449.0	361.0	51.5	314.0	3000.0	298.0	432.0
Na (mg/L)	2362.0	3276.0	3152.0	602.0	2356.0	15270.0	3754.0	9580.0
Na (mg/L)	2380.0	3254.0	3018.0	620.0	2360.0	15250.0	3760.0	9640.0
Na (mg/L)	2446.0	3248.0	2934.0	576.0	2378.0	15450.0	3726.0	9670.0
K (mg/L)	88.1	169.3	150.7	38.1	115.1	664.0	184.5	531.0
K (mg/L)	88.4	171.3	146.5	36.4	114.9	637.0	182.6	543.0
K (mg/L)	87.5	172.3	148.3	34.9	119.5	646.0	187.4	533.0
nitrate (mg/L)	1.4	3.1	1.3	1.3	2.8	10.1	24.8	10.4
nitrate (mg/L)	2.3	3.2	2.2	0.9	2.7	9.9	14.3	9.8

nitrate (mg/L)	2.3	3.1	2.4	0.9	2	9.6	22.7	9.5
nitrite (mg/L)	0.023	0.17	<dl	0.02	0.019	0.583	0.036	0.013
nitrite (mg/L)	0.024	0.159	<dl	0.015	0.014	0.605	0.035	0.015
nitrite (mg/L)	0.022	0.181	<dl	0.013	0.015	0.605	0.038	0.014
ammonia (mg/L)	0.15	0.4	<dl	<dl	<dl	0.4	30	70
ammonia (mg/L)	0.17	0.3	<dl	<dl	<dl	0.4	40	60
ammonia (mg/L)	0.18	0.3	<dl	<dl	<dl	0.4	30	60
orthophosphates (mg/L)	0.23	0.4	0.1	0.78	0.12	0.67	0.45	0.25
orthophosphates (mg/L)	0.18	0.46	0.13	0.85	0.1	0.6	0.36	0.23
orthophosphates (mg/L)	0.14	0.41	0.09	0.9	0.01	0.63	0.37	0.26

Results of the second group of samples

Table 6 Values of pH, TDS and EC for second group of ground and surface samples

SAMPLE	pH	TDS (mg/L)	EC (µS/cm)
SW 1	6.47	3350	6700
SW 2	7.00	1600	3200
SW 3	7.18	934	1867
SW 4	7.28	498	996
SW 5	7.28	1619	3240
SW 6	6.93	858	1716
SW 7	7.09	2020	4050
SW 8	7.09	7100	14200
SW 9	7.27	1175	2350
SW 10	6.96	1794	3590
SW 11	7.28	472	944
SW 12	6.87	2050	4090
SW 13	6.83	2390	4780
SW 14	6.96	2100	4190
SW 15	7.06	1601	3200
SW 16	7.25	1352	2700
SW 17	7.27	18440	36900
SW 18	7.54	349	698
SW 19	7.08	375	749
SW 20	7.06	455	911
SW 21	7.04	425	850
SW 22	6.76	1103	2210
SW 23	6.97	2600	5200
SW 24	6.67	9280	18550
GW 1	6.44	31200	62300
GW 2 0,5m	6.78	22800	45700
GW 2 5,0m	6.82	25300	50600
GW 3	7.07	11090	22200
GW 4 0,5m	6.70	1241	2480
GW 4 5,0m	6.75	1162	2320
GW 5 0,5	6.33	13350	26700
GW 5 5,0	6.42	18130	36300
GW 6	7.22	17520	35000
GW 7	7.54	21400	42800

Table 7 Values of CO3 + HCO3, Cl-, SO42-, Ca, Mg, Na, K for second group of ground and surface samples

SAMPLE	$CO_3 + HCO_3$	Cl- (mg/L)	SO_4^{2-} (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)
SW 1	270.00	2900.00	225.00	155.50	152.0	1024.0	83.10
SW 2	201.50	1166.00	118.00	96.30	75.0	527.0	37.12
SW 3	182.50	550.00	80.00	29.20	61.0	346.0	19.10
SW 4	160.00	600.00	42.00	54.82	36.0	214.0	8.68
SW 5	180.00	200.00	136.00	30.00	83.0	565.0	29.28
SW 6	190.00	700.00	70.00	10.00	48.0	296.0	11.62
SW 7	197.50	1533.00	136.00	27.70	96.0	648.0	40.40
SW 8	202.50	4800.00	570.00	152.60	320.0	2554.0	172.20
SW 9	180.00	400.00	108.00	66.82	71.0	396.0	17.70
SW 10	195.00	1700.00	140.00	27.50	92.0	593.0	31.82
SW 11	170.00	500.00	46.00	98.86	42.0	218.0	5.00
SW 12	195.00	1700.00	138.00	22.70	102.0	666.0	32.50
SW 13	205.00	2100.00	215.00	38.30	117.0	766.0	38.50
SW 14	225.00	2000.00	185.00	34.10	106.0	678.0	34.02
SW 15	180.00	1100.00	126.00	27.10	89.0	540.0	25.04
SW 16	172.50	1200.00	120.00	16.30	87.0	463.0	20.02
SW 17	157.50	20100.00	1750.00	304.10	1014.0	8715.0	3,310.00
SW 18	167.50	500.00	40.00	55.48	53.0	221.0	3.28
SW 19	162.50	500.00	38.00	54.42	50.0	245.0	3.94
SW 20	171.50	433.00	47.30	56.34	52.0	250.0	4.80
SW 21	175.00	500.00	44.00	52.78	53.0	251.0	4.60
SW 22	270.00	600.00	76.00	30.20	74.0	437.0	16.24
SW 23	230.00	1300.00	240.00	66.90	140.0	893.0	38.72
SW 24	262.50	7400.00	650.00	233.90	449.0	3752.0	323.20
GW 1	105.00	29200.00	2800.00	1203.00	1745.0	23320.0	1,406.00
GW 2 0,5m	230.00	22900.00	2000.00	550.70	1062.0	13780.0	1,037.00
GW 2 5,0m	205.00	22400.00	2200.00	607.80	1206.0	15210.0	966.00
GW 3	855.00	10100.00	240.00	182.10	459.0	10520.0	674.00
GW 4 0,5m	525.00	500.00	104.00	239.90	98.0	501.0	173.00
GW 4 5,0m	532.50	400.00	96.00	233.10	90.0	467.0	205.00
GW 5 0,5	1592.50	10900.00	30.00	211.20	530.0	17320.0	699.00
GW 5 5,0	1970.00	16800.00	50.00	257.60	818.0	13530.0	1,186.00
GW 6	232.50	17900.00	460.00	354.40	532.0	13710.0	765.00
GW 7	35.00	21100.00	1200.00	872.00	422.0	13440.0	1,127.00

Table 8 Values of nitrates, nitrites, ammonia and orthophosphates for second group of ground and surface samples

SAMPLE	nitrates (mg/L)	nitrites (mg/L)	ammonia (mg/L)	orthophosphates (mg/L)
SW 1	3.00	0.007	4.00	5.30
SW 2	1.46	0.026	0.20	1.43
SW 3	1.00	0.019	0.03	1.70
SW 4	0.80	0.021	0.01	1.40
SW 5	1.80	0.004	0.16	2.50
SW 6	0.90	0.030	0.03	0.20
SW 7	1.50	0.021	0.26	0.39
SW 8	4.30	0.034	0.07	0.34
SW 9	1.10	0.029	0.03	0.56
SW 10	0.90	0.032	<DL	0.23
SW 11	0.50	0.027	0.02	0.28
SW 12	0.80	0.009	0.01	0.32
SW 13	1.40	0.045	0.32	0.36
SW 14	2.10	0.162	0.50	0.32
SW 15	0.70	0.042	0.06	0.19
SW 16	0.70	0.020	0.04	0.19
SW 17	5.40	0.020	0.01	0.14
SW 18	0.80	0.019	0.07	0.17
SW 19	0.40	0.016	0.01	0.29
SW 20	<DL	0.016	0.02	0.63
SW 21	0.40	0.019	<DL	0.15
SW 22	0.70	0.02	0.21	0.83
SW 23	0.90	0.025	<DL	0.09
SW 24	2.80	0.017	<DL	0.14
GW 1	14.50	0.460	0.35	0.34
GW 2 0,5m	7.00	0.160	0.17	0.44
GW 2 5,0m	6.60	0.044	0.40	0.73
GW 3	21.60	0.350	38.00	0.56
GW 4 0,5m	1.20	0.029	0.12	0.26
GW 4 5,0m	2.70	0.028	0.10	0.82
GW 5 0,5	35.40	0.016	40.00	1.30
GW 5 5,0	41.40	0.042	100.00	0.59
GW 6	10.60	0.250	20.00	0.40
GW 7	16.60	0.830	0.10	0.20

Table 9 Statistics of the second group of samples

SAMPLE	SW 2	SW 7	SW 20
pH	7.00	7.09	7.05
pH	7.00	7.09	7.06
pH	6.99	7.09	7.07
TDS (mg/L)	1600	2030	455
TDS (mg/L)	1601	2020	455
TDS (mg/L)	1600	2020	455
EC (µS/cm)	3160	4050	911
EC (µS/cm)	3200	4050	911
EC (µS/cm)	3200	4050	910
CO_3 + HCO_3	200	200	167
CO_3 + HCO_3	205	195	172
CO_3 + HCO_3	200	197	175
Cl- (mg/L)	1100	1500	400
Cl- (mg/L)	1200	1600	400
Cl- (mg/L)	1200	1500	500
SO_4^{2-} (mg/L)	118.00	134.00	48.00
SO_4^{2-} (mg/L)	118.00	136.00	46.00
SO_4^{2-} (mg/L)	118.00	136.00	48.00
Ca (mg/L)	92.10	28.40	56.16
Ca (mg/L)	93.10	28.60	57.66
Ca (mg/L)	103.80	26.10	55.20
Mg (mg/L)	76.0	95.0	50.0
Mg (mg/L)	75.0	96.0	53.0
Mg (mg/L)	74.0	97.0	54.0
Na (mg/L)	523.0	651.0	250.0
Na (mg/L)	530.0	645.0	253.0
Na (mg/L)	527.0	648.0	247.0
K (mg/L)	36.76	40.40	4.90
K (mg/L)	37.62	40.52	4.80
K (mg/L)	36.98	40.30	4.66
nitrate (mg/L)	1.40	1.40	<DL
nitrate (mg/L)	1.50	1.60	<DL

nitrate (mg/L)	1.50	1.50	<DL
nitrite (mg/L)	0.025	0.018	0.019
nitrite (mg/L)	0.031	0.024	0.009
nitrite (mg/L)	0.021	0.021	0.020
ammonia (mg/L)	0.20	0.27	0.02
ammonia (mg/L)	0.19	0.25	0.03
ammonia (mg/L)	0.20	0.25	0.02
orthophosphates (mg/L)	1.4	0.33	0.60
orthophosphates (mg/L)	1.3	0.42	0.80
orthophosphates (mg/L)	1.4	0.42	0.50

Results of the third group of samples

Table 10 Values of pH, TDS and EC for third group of ground and surface samples

SAMPLE	pH	TDS (mg/L)	EC (µS/cm)
SW 1	7.19	5610	11220
SW 2	7.40	3010	6020
SW 3	7.53	432	865
SW 4	7.78	645	1290
SW 5	7.85	203	406
SW 6	7.54	1044	2090
SW 7	7.52	2240	4480
SW 8	7.64	11550	23100
SW 9	7.48	1649	3300
SW 10	7.30	2430	4860
SW 11	7.49	1237	2470
SW 12	7.53	2590	5190
SW 13	7.51	4180	8360
SW 14	7.69	3060	6110
SW 15	7.24	3750	7500
SW 16	7.74	185	370
SW 17	7.78	404	808
SW 18	7.58	480	960
SW 19	7.47	703	1405
SW 20	7.46	1026	2050
SW 21	7.43	1110	2220
SW 22	7.49	1335	2670
SW 23	7.45	3910	7820
SW 24	7.29	5910	11820
GW 1	7.34	28200	56300
GW 2 0,5m	7.54	24800	49600
GW 2 5,0m	7.57	24900	49800
GW 3	7.64	11000	22000
GW 4 0,5m	7.04	1148	2300
GW 4 5,0m	7.07	1180	2360
GW 5 0,5	7.51	1632	3260
GW 5 5,0	7.31	4380	8750
GW 6	7.85	17280	34600
GW 7	7.97	21400	42700

Table 11 Values of CO3 + HCO3, Cl-, SO42-, Ca, Mg, Na, K for third group of ground and surface samples

SAMPLE	CO3 + HCO3	Cl- (mg/L)	SO_4^{2-} (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)
SW 1	300.00	6000.00	360.00	202.00	233.0	2239.0	81.30
SW 2	280.00	1505.00	330.00	185.00	169.0	1585.0	190.30
SW 3	217.50	170.00	34.00	67.20	94.0	888.0	68.30
SW 4	205.00	306.00	56.00	62.80	65.0	279.0	46.10
SW 5	177.50	40.00	18.00	46.60	67.0	316.0	112.60
SW 6	230.00	630.00	92.00	82.20	94.0	325.0	37.80
SW 7	276.50	1455.00	326.60	161.00	126.0	644.0	57.90
SW 8	270.00	285.00	270.00	268.60	448.0	4624.0	203.60
SW 9	317.50	593.50	340.00	190.40	108.0	453.0	39.80
SW 10	370.00	1086.00	360.00	297.50	145.0	640.0	48.80
SW 11	280.00	634.00	305.00	132.50	92.0	367.0	50.10
SW 12	280.00	1760.00	300.00	236.30	143.0	788.0	54.30
SW 13	290.00	3278.00	335.00	215.10	198.0	1375.0	68.60
SW 14	350.00	2500.00	210.00	193.50	154.0	999.0	58.10
SW 15	595.00	2400.00	150.00	252.10	197.0	1263.0	61.30
SW 16	184.15	31.00	17.00	26.40	72.0	264.0	14.90
SW 17	177.50	158.00	40.00	27.40	75.0	340.0	18.10
SW 18	210.00	200.00	12.00	46.80	88.0	328.0	18.40
SW 19	190.00	635.00	40.00	47.10	88.0	377.0	20.00
SW 20	245.00	252.00	110.00	75.90	93.0	498.0	26.80
SW 21	255.00	300.00	115.00	115.00	87.0	511.0	27.60
SW 22	325.00	450.00	170.00	105.80	91.0	627.0	35.30
SW 23	255.00	2500.00	300.00	171.40	179.0	1383.0	59.80
SW 24	282.50	4360.00	530.00	230.30	256.0	2014.0	88.70
GW 1	100.00	11600.00	2600.00	723.00	1415.0	10785.0	979.00
GW 2 0,5m	235.00	12360.00	2400.00	403.70	1265.0	9130.0	505.00
GW 2 5,0m	225.00	22500.00	2200.00	389.30	1245.0	8835.0	544.00
GW 3	890.00	7200.00	310.00	85.20	389.0	4575.0	192.00
GW 4 0,5m	630.00	336.00	76.00	126.60	125.0	278.0	45.40
GW 4 5,0m	647.50	473.00	42.00	130.30	105.0	283.0	39.10
GW 5 0,5	897.50	480.00	580.00	32.10	120.0	644.0	63.20
GW 5 5,0	1037.50	2650.00	300.00	79.70	154.0	1390.0	117.20
GW 6	310.00	8120.00	440.00	198.10	416.0	6985.0	159.00
GW 7	55.00	22710.00	1500.00	471.00	585.0	8040.0	89.00

Table 12 Values of nitrates, nitrites, ammonia and orthophosphates for third group of ground and surface samples

SAMPLE	nitrates (mg/L)	nitrites (mg/L)	ammonia (mg/L)	orthophosphates (mg/L)
SW 1	3.54	0.016	0.50	1.28
SW 2	2.21	0.148	0.36	1.04
SW 3	1.33	<dl	0.23	0.21
SW 4	1.33	0.012	0.02	0.20
SW 5	1.33	0.019	0.02	11.90
SW 6	0.89	0.017	<dl	23.20
SW 7	2.66	0.164	0.07	0.53
SW 8	6.20	0.213	1.10	0.40
SW 9	2.21	0.235	0.40	0.37
SW 10	2.21	0.345	1.80	0.62
SW 11	1.33	0.104	0.50	0.48
SW 12	2.21	0.242	0.02	0.29
SW 13	1.77	0.180	48.00	0.64
SW 14	2.66	0.376	0.25	0.41
SW 15	3.98	0.014	3.90	2.19
SW 16	0.89	0.020	<dl	0.19
SW 17	0.89	0.016	0.16	0.13
SW 18	0.89	0.023	0.02	0.17
SW 19	0.44	0.016	<dl	0.19
SW 20	0.89	0.056	<dl	0.35
SW 21	1.33	0.066	0.26	0.27
SW 22	0.44	<dl	0.27	18.00
SW 23	1.77	0.017	<dl	1.13
SW 24	3.54	0.027	0.52	0.39
GW 1	2.66	0.600	0.20	0.28
GW 2 0,5m	5.31	1.200	0.08	0.60
GW 2 5,0m	5.31	1.200	0.09	1.39
GW 3	13.28	3.000	<dl	0.50
GW 4 0,5m	0.44	0.100	0.19	0.18
GW 4 5,0m	0.89	0.200	0.47	0.12
GW 5 0,5	1.33	0.300	0.27	0.30
GW 5 5,0	4.87	1.100	6.00	0.42
GW 6	5.76	1.300	24.00	0.34
GW 7	11.51	2.600	10.00	0.10

Table 13 Statistics of the third group of samples

SAMPLE	SW 3	SW 7	SW 16
pH	7.54	7.54	7.73
pH	7.53	7.51	7.73
pH	7.53	7.51	7.76
TDS (mg/L)	432	2240	185
TDS (mg/L)	432	2240	185
TDS (mg/L)	433	2240	185
EC (µS/cm)	863	4480	371
EC (µS/cm)	864	4480	370
EC (µS/cm)	867	4480	370
CO_3 + HCO_3	220	280	180
CO_3 + HCO_3	218	275	190
CO_3 + HCO_3	215	275	183
Cl- (mg/L)	1880	1445	26
Cl- (mg/L)	1525	1445	44
Cl- (mg/L)	1695	1475	24
SO_4^{2-} (mg/L)	34.00	300.00	15.00
SO_4^{2-} (mg/L)	34.00	345.00	19.00
SO_4^{2-} (mg/L)	34.00	335.00	17.00
Ca (mg/L)	67.20	161.00	26.40
Ca (mg/L)	66.80	161.30	26.40
Ca (mg/L)	67.70	160.60	26.30
Mg (mg/L)	94.0	126.0	72.0
Mg (mg/L)	94.0	123.0	71.0
Mg (mg/L)	95.0	130.0	72.0
Na (mg/L)	888.0	644.0	26.4
Na (mg/L)	880.0	640.0	26.2
Na (mg/L)	896.0	648.0	26.6
K (mg/L)	68.30	57.90	14.90
K (mg/L)	68.60	58.70	13.90
K (mg/L)	68.10	57.10	15.80
nitrate (mg/L)	1.33	2.66	0.44
nitrate (mg/L)	1.33	2.66	0.88

nitrate (mg/L)	1.33	2.21	0.88
nitrite (mg/L)	< dl	169.000	0.021
nitrite (mg/L)	<dl	0.150	0.023
nitrite (mg/L)	<dl	0.175	0.017
ammonia (mg/L)	0.01	0.02	<dl
ammonia (mg/L)	0.02	0.09	<dl
ammonia (mg/L)	0.04	0.10	<dl
orthophosphates (mg/L)	0.24	0.48	0.14
orthophosphates (mg/L)	0.22	0.65	0.21
orthophosphates (mg/L)	0.17	0.45	0.22

Results of the fourth group of samples

Table 14 Values of pH, TDS and EC for fourth group of ground and surface samples

SAMPLE	pH	TDS (mg/L)	EC (µS/cm)
SW 1	7.14	4530	9060
SW 2	7.11	2480	4950
SW 3	7.41	353	706
SW 4	7.40	469	939
SW 5	7.70	205	411
SW 6	7.40	428	856
SW 7	7.22	2900	5810
SW 8	7.47	8140	16290
SW 9	7.44	1898	3800
SW 10	7.23	2330	4670
SW 11	7.38	1233	2470
SW 12	7.42	2550	5110
SW 13	7.36	3120	6240
SW 14	7.47	2680	5370
SW 15	7.60	1460	2920
SW 16	7.90	224	447
SW 17	7.65	398	799
SW 18	7.45	344	688
SW 19	7.44	439	878
SW 20	7.42	737	1474
SW 21	7.28	1217	2430
SW 22	7.24	1738	3480
SW 23	7.24	2100	4190
SW 24	7.19	1735	3470
GW 1	7.14	28000	56000
GW 2 0,5m	7.35	24600	49170
GW 2 5,0m	7.42	24600	49800
GW 3	7.61	10870	21700
GW 4 0,5m	7.04	1219	2440
GW 4 5,0m	7.01	1084	2170
GW 5 0,5	7.63	1370	2740
GW 5 5,0	7.48	1291	2580
GW 6	7.50	17130	34300
GW 7	7.95	21600	43100

Table 15 Values of CO3 + HCO3, Cl-, SO42-, Ca, Mg, Na, K for fourth group of ground and surface samples

SAMPLE	CO3 + HCO3	Cl- (mg/L)	SO_4^{2-} (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)
SW 1	402.50	4250.00	400.00	181.00	211.0	1378.0	900.00
SW 2	312.50	1800.00	3100.00	223.00	141.0	1049.0	2,138.00
SW 3	230.00	78.00	22.00	153.00	46.0	431.0	2,088.00
SW 4	210.00	285.00	34.00	81.30	42.0	174.0	739.00
SW 5	207.50	42.00	24.00	78.40	28.0	97.0	717.00
SW 6	260.00	425.00	40.00	84.70	41.0	177.0	783.00
SW 7	322.50	2275.00	320.00	67.00	123.0	720.0	710.00
SW 8	339.00	11366.00	597.00	301.50	388.0	1967.0	1,081.00
SW 9	354.50	1155.00	520.00	180.00	114.0	646.0	1,212.00
SW 10	450.00	1610.00	610.00	421.00	143.0	1124.0	2,348.00
SW 11	322.50	645.00	340.00	155.00	85.0	473.0	1,268.00
SW 12	390.00	2240.00	600.00	149.00	135.0	666.0	696.00
SW 13	485.00	3015.00	350.00	125.00	136.0	810.0	845.00
SW 14	455.00	3640.00	340.00	129.00	140.0	818.0	876.00
SW 15	400.00	950.00	110.00	163.40	84.0	424.0	693.00
SW 16	225.00	32.50	21.00	60.60	40.0	148.0	775.00
SW 17	230.00	151.00	25.70	70.70	49.0	233.0	855.00
SW 18	235.00	94.00	22.00	61.40	41.0	213.0	859.00
SW 19	230.00	166.00	20.00	72.00	43.0	182.0	717.00
SW 20	272.50	350.00	130.00	97.80	54.0	247.0	734.00
SW 21	330.00	660.00	350.00	88.00	75.0	332.0	702.00
SW 22	397.50	130.00	300.00	103.00	88.0	418.0	694.00
SW 23	327.50	5300.00	230.00	155.80	101.0	618.0	745.00
SW 24	310.00	1300.00	220.00	139.40	86.0	498.0	738.00
GW 1	125.00	37400.00	2900.00	1096.00	1610.0	13350.0	2,095.00
GW 2 0,5m	207.50	36830.00	2200.00	486.00	1515.0	14390.0	1,216.00
GW 2 5,0m	232.50	2400.00	2266.00	341.00	1490.0	10715.0	728.00
GW 3	895.00	4540.00	320.00	105.90	400.0	5590.0	314.00
GW 4 0,5m	625.00	425.00	270.00	166.10	90.0	290.0	201.00
GW 4 5,0m	615.00	300.00	250.00	173.80	80.0	289.0	184.00
GW 5 0,5	775.00	420.00	240.00	108.00	92.0	863.0	700.00
GW 5 5,0	815.00	270.00	230.00	36.70	60.0	465.0	206.00
GW 6	357.50	20440.00	440.00	181.00	427.0	7325.0	533.00
GW 7	57.50	27730.00	1500.00	633.00	825.0	8980.0	702.00

Table 16 Values of nitrates, nitrites, ammonia and orthophosphates for fourth group of ground and surface samples

SAMPLE	nitrates (mg/L)	nitrites (mg/L)	ammonia (mg/L)	orthophosphates (mg/L)
SW 1	2.90	0.016	6.50	4.20
SW 2	1.60	0.094	0.12	0.90
SW 3	0.70	0.020	0.04	0.80
SW 4	1.00	0.031	0.02	0.40
SW 5	1.00	0.010	<DL	20.00
SW 6	0.40	0.014	<DL	5.10
SW 7	2.00	0.096	0.57	1.63
SW 8	5.00	0.272	1.66	0.64
SW 9	2.70	0.241	2.30	1.02
SW 10	2.90	0.342	2.60	0.68
SW 11	1.80	0.191	1.40	1.65
SW 12	2.00	0.041	0.13	0.92
SW 13	3.40	0.421	1.38	2.09
SW 14	3.20	0.423	0.99	5.50
SW 15	0.50	0.017	0.02	0.90
SW 16	1.20	0.011	<DL	3.00
SW 17	0.70	0.017	<DL	1.37
SW 18	0.70	0.020	<DL	0.35
SW 19	0.90	0.007	<DL	0.12
SW 20	1.20	0.040	0.19	0.20
SW 21	1.40	0.125	12.00	0.56
SW 22	2.50	0.351	2.20	2.40
SW 23	1.40	0.066	0.18	1.00
SW 24	0.80	0.032	0.06	0.19
GW 1	4.00	0.074	0.60	0.20
GW 2 0,5m	5.10	0.082	0.38	0.82
GW 2 5,0m	4.90	0.037	0.36	0.83
GW 3	13.00	0.109	0.46	1.65
GW 4 0,5m	0.80	0.092	0.97	0.09
GW 4 5,0m	1.00	0.090	0.52	0.06
GW 5 0,5	0.80	0.047	<DL	1.55
GW 5 5,0	0.30	0.010	4.00	1.86
GW 6	8.40	0.600	4.00	0.85
GW 7	9.30	0.550	119.00	0.05

Table 17 Statistics of the fourth group of samples

SAMPLE	SW 8	SW 17	GW 2 5,0
pH	7.45	7.66	7.42
pH	7.46	7.65	7.41
pH	7.49	7.64	7.43
TDS (mg/L)	8260	398	24900
TDS (mg/L)	8090	398	24500
TDS (mg/L)	8080	399	24400
EC (µS/cm)	16510	799	49800
EC (µS/cm)	16180	799	49000
EC (µS/cm)	16170	798	48700
CO_3 + HCO_3	347	230	230
CO_3 + HCO_3	337	230	235
CO_3 + HCO_3	335	225	232
Cl- (mg/L)	11600.00	150.00	2600.00
Cl- (mg/L)	11650.00	148.00	2500.00
Cl- (mg/L)	10850.00	156.00	2100.00
SO_4^{2-} (mg/L)	600.00	26.00	2400.00
SO_4^{2-} (mg/L)	600.00	26.00	2400.00
SO_4^{2-} (mg/L)	590.00	25.00	2000.00
Ca (mg/L)	290.70	69.20	308.00
Ca (mg/L)	302.60	71.60	352.00
Ca (mg/L)	311.20	71.10	364.00
Mg (mg/L)	383.0	50.0	1480.0
Mg (mg/L)	389.0	48.0	1505.0
Mg (mg/L)	393.0	48.0	1480.0
Na (mg/L)	1939.0	234.0	10770.0
Na (mg/L)	1980.0	232.0	10680.0
Na (mg/L)	1984.0	234.0	10705.0
K (mg/L)	1085.00	850.00	719.00
K (mg/L)	1090.00	853.00	743.00
K (mg/L)	1067.00	862.00	722.00
nitrate (mg/L)	4.90	0.90	4.80
nitrate (mg/L)	5.10	0.60	5.00

nitrate (mg/L)	5.00	0.60	5.00
nitrite (mg/L)	0.243	0.012	4.800
nitrite (mg/L)	0.295	0.020	5.000
nitrite (mg/L)	0.279	0.018	5.000
ammonia (mg/L)	1.70	<DL	0.33
ammonia (mg/L)	1.70	<DL	0.36
ammonia (mg/L)	1.60	<DL	0.39
orthophosphates (mg/L)	0.61	1.40	0.85
orthophosphates (mg/L)	0.65	1.60	0.88
orthophosphates (mg/L)	0.65	1.10	0.77

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