water

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Article

Possible Sources of Salinity in the Upper Dibdibba Aquifer, Basrah, Iraq

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Supplementary Materials

Table S1. Geological sequence showing Formations names, age, and depth from the surface, inferred from well Ru–441 in Rumaila oilfield [1,2].

Age	Formation	Depth (m)
Miocene –Pleistocene	Dibdibba	Surface
	Fatha (Lower Fars)	162
	Ghar	279
Eocene	Dammam	430
Paleocene	Rus	660
	Umm Er–Radhuma	829

Table S2. Field parameters (Temp. pH, Eh, EC), elevation and the coordinate of groundwater samples and KhZ in the AOI.

ID	Longitude	Latitude	Elevation [m]	EC [μS/cm]	T [°C]	pH	Eh [mV]
W 1	47° 44′ 35.7″	30° 19′ 13.5″	6	8000	27.0	7.4	174
W 2	47° 44′ 59.9″	30° 18′ 17.4″	6	7370	28.0	7.09	165
W 3	47° 47′ 33.6″	30° 13′ 28.2″	7	8010	27.5	7.07	159
W 4	47° 48′ 25.1″	30° 12′ 23.6″	7	9280	26.8	7.64	149
W 5	47° 49′ 42.5″	30° 09′ 42.5″	2	9320	26.0	7.28	165
W 6	47° 51′ 28.7″	30° 07′ 14.6″	2	11,310	28.2	7.35	161
W 7	47° 50′ 42.6″	30° 08′ 4.1″	2	13,340	29.7	7.43	173
W 8	47° 44′ 30.4″	30° 19′ 40.6″	1	10,280	28.0	7.35	162
W 9	47° 38′ 21.6″	30° 07′ 38.3′	27	8180	29.0	7.53	174
W 10	47° 37′ 50.9″	30° 08′ 34.4″	17	8170	28.5	7.35	161
W 11	47° 38′ 05.0″	30° 09′ 30.1″	13	11,730	28.5	7.16	172
W 12	47° 37′ 2.1″	30° 09′ 41.7″	16	11,050	28.2	7.13	154
W 13	47° 36′ 52.1″	30° 08′ 07.2″	34	11,700	29.3	7.46	176
W 14	47° 36′ 25.6″	30° 08′ 31.8″	22	10,900	28.0	7.56	151
W 15	47° 36′ 37.4″	30° 08′ 56.6″	25	10,810	28.8	7.41	170
W 16	47° 43′ 05.6″	30° 07′ 36″	8	12,280	29.0	6.97	183
W 17	47° 42′ 56.4″	30° 06′ 46.5″	3	10,810	29.3	7.16	195
W 18	47° 40′ 50.3″	30° 07′ 00.9″	4	12,950	27.8	7.44	173
W 19	47° 39′ 20.3″	30° 07′ 0.22″	11	10,040	29.4	7.50	189
W 20	47° 40′ 35.7″	30° 06′ 20.6″	9	7710	27.0	7.67	171
W 21	47° 42′ 45.2″	30° 17′ 11.7″	12	16,330	27.3	7.18	177
W 22	47° 42′ 15″	30° 15′ 50″	12	9000	26.4	7.37	198
W 23	47° 42′ 39.5″	30° 14′ 06.1″	12	11,730	27.3	7.12	204
W 24	47° 43′ 46.4″	30° 12′ 41.5″	8	18,040	27.3	7.18	208
W 25	47° 44′ 24″	30° 11′ 27.1″	8	12,080	28.0	7.43	203
W 26	47° 44′ 48.3″	30° 06′ 37.2″	8	10,010	26.0	7.6	199
W 27	47° 41′ 06.1″	30° 12′ 21.9″	4	14,270	28.5	7.47	204
W 28	47° 40′ 20″	30° 13′ 46.6″	9	13,760	28.0	7.34	196
W 29	47° 39′ 02.7″	30° 14′ 33.7″	12	13,560	28.7	7.26	178
W 30	47° 37′ 01.9″	30° 17′ 44.0″	12	14,650	27.5	7.14	196
W 31	47° 36′ 23.3″	30° 19′ 29.3″	7	20,900	27.8	7.39	184
W 32	47° 40′ 47.5″	30° 15′ 01.1″	8	12,880	29.0	7.27	185
W 33	47° 42′ 12.1″	30° 24′ 22.5″	20	8450	26.5	7.27	190
W 34	47° 43′ 01.0″	30° 21′ 24.2″	10	6140	27.0	7.47	162
W 36	47° 54′ 30.1″	30° 03′ 17.5″	8	17,950	28.0	7.26	171
W 37	47° 55′ 23.3″	30° 02′ 17.0″	8	8050	28.0	6.88	165
W 38	47° 53′ 45.8″	30° 03′ 48.3″	12	17,510	28.0	7.44	110
W 39	47° 35′ 15″	30° 20′ 07.9″	11	14,980	28.0	7.05	189
W 40	47° 34′ 03.2″	30° 21′ 49.4″	7	16,920	29.0	7.19	198
KhZ	47° 53′ 48″	30° 09′ 20.7″	0	69,700	20.0	8.23	154

Table S3. Chemical analysis and Na^+/Cl^-, Cl^-/HCO_3^- and Cl^-/Br^- ratios of groundwater samples in the AOI, and mean and standard deviation (SD).

ID	Na^+ [mg/L]	Cl^- [mg/L]	SO_4^{2-} [mg/L]	Br^- [mg/L]	HCO_3^- [mg/L]	Na^+/Cl^- Molar ratio	Cl^-/HCO_3^- Molar ratio	Cl^-/Br^- Molar ratio
W1	1300	1170	2360	1.554	97	1.7	20.8	1694.02
W2	960	960	1870	2.305	133	1.6	12.4	937.09
W3	1090	1650	2300	3.993	85	1.0	32.9	929.75
W4	1670	1440	3270	3.223	104	1.8	24.0	1005.27
W5	1230	1700	2450	2.859	101	1.1	29.1	1337.88
W6	2130	2380	2770	5.713	103	1.4	39.7	937.34
W7	2180	2740	2580	7.977	20	1.2	233.3	772.85
W8	1850	2100	2780	2.596	111	1.4	32.4	1820.11
W9	1500	1660	2420	2.907	55	1.4	52.2	1284.83
W10	1060	1300	2170	1.808	86	1.2	26.2	1617.81
W11	1810	3190	2120	6.346	71	0.9	76.9	1131.03
W12	1250	2270	2780	2.76	84	0.8	46.7	1850.54
W13	2175	3070	2550	5.1	55	1.1	96.7	1354.33
W14	1600	2200	1990	4.761	76	1.1	50.0	1039.70
W15	1570	2010	2240	3.485	71	1.2	48.7	1297.70
W16	1900	2250	2020	6.84	69	1.3	55.8	740.13
W17	1300	1800	2020	3.754	350	1.1	8.9	1078.85
W18	2060	2600	2940	5.835	75	0.9	82.1	1002.57
W19	1720	2330	2540	4.427	65	1.1	61.7	1184.21
W20	1170	1240	2230	2.626	65	1.5	33.0	1062.45
W21	2910	4890	2360	10.6	112	0.9	75.0	1037.97
W22	1190	1600	2270	3.863	84	1.2	31.9	931.92
W23	1900	2930	2470	7.064	126	1.0	40.1	933.25
W24	3530	5160	3620	12.02	137	1.1	65.2	965.89
W25	1700	2240	2690	5.243	97	1.2	39.6	961.28
W26	1330	1940	1970	4.311	34	1.1	98.2	1012.53
W27	2310	3970	2940	7.907	39.65	0.9	172.3	1129.70
W28	2330	3470	2450	7.504	40	1.0	153.1	1040.45
W29	2280	3820	2610	7.717	59	0.9	112.5	1113.77
W30	2270	4310	2460	9.577	95	0.8	78.7	1012.58
W31	4720	5850	3810	16.4	182	1.2	55.2	802.59
W32	1800	3320	2470	6.603	64	0.8	89.5	1131.30
W33	1430	1330	3020	1.985	66	1.7	34.3	1507.56
W34	940	670	2700	1.261	101	2.2	11.5	1195.57
W36	3920	4230	4680	9.991	149	1.4	48.8	952.61
W37	1190	1440	2450	2.473	201	1.3	12.5	1310.10
W 38	3970	4800	4210	10.77	111	1.3	74.2	1002.79
W39	2310	4190	2210	12.53	80	0.9	90.1	752.39
W40	2070	3870	2760	7.869	102	0.8	65.3	1106.56
Min.	940	670	1870	1.26	20			
Max.	4720	5850	4680	16.4	350			
Mean	1940	2700	2655	5.8	96			
SD	864	1310	609	3.5	86			
KhZ	16,540	28,360	4420	145	103	0.9	476.2	440.07

Table S4. Stable isotopes $\delta^{18}O$, $\delta^{2}H$, d-excess and EC in the AOI at different sampling points, with the mean and standard deviation (SD).

ID	$\delta^{2}H$ ‰	$\delta^{18}O$ ‰	EC [µS/cm]	d-excess ‰
W 1	−12.13	–1.31	8000	–1.65
W 2	–16.26	–2.07	7370	0.3
W 3	–16.38	–2.51	8010	3.7
W 4	–9.17	–1.36	9280	1.71
W 5	–14.9	–2.6	9320	5.9
W 6	–6.65	–0.78	11,310	–0.41
W 7	–8.91	–0.76	13,340	–2.83
W 8	–4.88	–0.26	10,280	–2.8
W 9	–2.21	–0.04	8180	–1.89
W 10	–5.18	–1.36	8170	5.7
W 11	–4.78	–0.72	11,730	0.98
W 12	–5.74	–0.78	11,050	0.5
W 13	–6.46	–0.76	11,700	–0.38
W 14	–7	–1.06	10,900	1.48
W 15	–7.02	–0.94	10,810	0.5
W 16	–10.94	–1.15	12,280	–1.74
W 17	–17.1	–3.06	10,810	7.38
W 18	–2.05	0.09	12,950	–2.77
W 19	–3.93	–0.4	10,040	–0.73
W 20	–3.05	–0.46	7710	0.63
W 21	–0.75	0.69	16,330	–6.27
W 22	–1.3	0.1	9000	–2.1
W 23	–6.41	–0.93	11,730	1.03
W 24	1.58	0.74	18,040	–4.34
W 25	3.49	1.24	12,080	–6.43
W 26	–0.59	0.58	10,010	–5.23
W 27	–5.69	–0.1	14,270	–4.89
W 28	–2.43	0.25	13,760	–4.43
W 29	0.11	0.8	13,560	–6.29
W 30	1.53	0.96	14,650	–6.15
W 31	–1.12	–0.14	20,900	0
W 32	2.53	1.12	12,880	–6.43
W 33	–17.77	–3.1	8450	7.03
W 34	–8.86	–1.08	6140	–0.22
W 36	–9.54	–1	17,950	–1.54
W 37	–18.63	–2.96	8050	5.05
W 38	–6.32	–0.48	17,510	–2.48
W 39	–2.35	0.19	14,980	–3.87
W 40	1.06	0.52	16,920	–3.1
Min	–18.63	–3.1	6140	–6.43
Max	3.49	1.24	20,900	7.38
Mean	–6.056	–0.638	11,806.4	–0.951
SD	5.976	1.155	3466.60	3.782
KhZ	21.09	3.4	69700	–6.11
Rainfall	–10.20	–2.79	–	12.12

References

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2. Jaffar, H.M.; Abdulnaby, W. Stress Regime of Rumania Oilfield in Southern Iraq from Borehole Breakouts. *IOSR–JAGG* **2018**, *6*, 25–35.