Hydrogeochemistry and carbonate saturation model of groundwater, Khanyounis Governorate – Gaza Strip, Palestine

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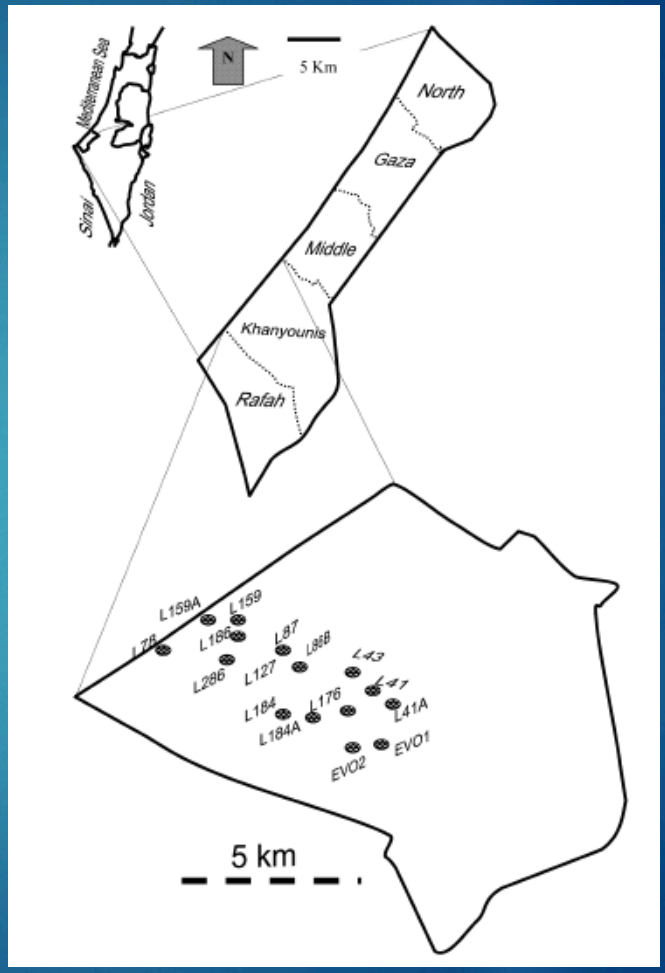
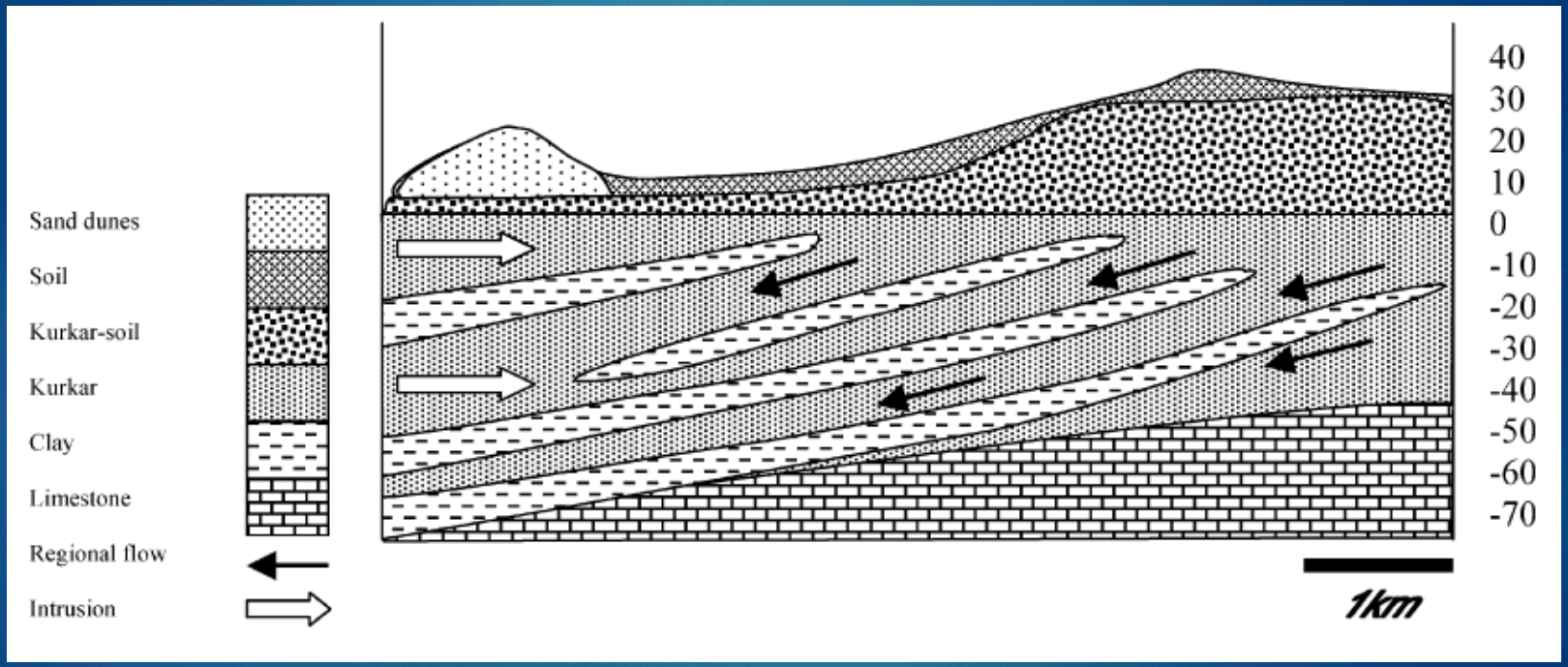
Khanyounis Governorate

- Located in southern Gaza Strip
- Population is approx. 120,000
- Groundwater is only regular source for water
- Annual precipitation 200-250mm
- Water polluted with Cl and NO3
  - Seawater
  - Fertilizers
  - Overpumping



Hydrogeological Cross Section



Original Chemical Analysis

Table 1 Chemical analysis of groundwater in Khanyounis Governorate (mg L^{-1})

Well No.	EC	TDS	pH	Alk	F	Ca	Mg	Na	K	Cl	NO_3	HCO_3	SO_4
L159	3,120	1,888	7.97	639	1.71	168	53.3	265	7.34	486	433	260	82
L176	3,385	2,048	8.12	440	1.43	87.8	53.6	460	5.5	838	106	161	296
L159A	2,353	1,424	7.78	522	0.92	128.6	48.6	180	4.62	324	363	240	42
L178	5,837	3,532	8.2	411	1.7	70	57.3	950	8.5	1,290	61	366	527
L184A	1,509	912	7.9	362	0.98	74	43	152.5	3.6	282	114	169	103
L184	760	460	8.12	159	1.6	32.3	19.2	106	1.6	134	90	159	28
L41A	191	116	6.9	35	0.56	3.8	6.3	61	0.4	77	34	20	10
L43	4,065	2,460	7.7	733	1.12	135.5	95.6	460	6.2	718	383	412	178
L86B	4,211	2,548	8.16	387	1.68	64	55.3	750	9.2	1,120	41	204	217
L87	568	344	7.43	52	0.5	7.7	8.1	95	1.2	98	115	38	2.9
L286	826	500	8.14	170	1.2	36.2	19.3	102	2.1	134	87	164	25
L127	3,424	2,072	7.92	666	1.1	134	80.5	400	4.4	690	371	189	106
L41	4,786	2,896	7.85	346	1.24	63.14	45.8	780	5	972	200	315	402
EVO1	393	480	8.14	444	1.43	31.6	15.9	102	1.7	112	64	171	26
EVO2	641	338	8.26	105	1.6	18.5	14.3	25	1.9	84	18	184	42

Descriptive Statistics

Table 2 Descriptive statistics of the analyzed chemical components (No. of samples 15)

Parameter	Minimum	Maximum	Mean	SD
EC	192	5,837	2,404	1,840
TDS	116	3,532	1,467	1,099
pH	6.90	8.26	7.90	0.3567
Alk	35.7	733.0	365	222
F	0.50	1.71	1.25	0.39
Ca	4	168	70	51
Mg	6.3	95.6	41	26
Na	25	950	325	296
K	0.40	9.20	4.21	2.75
Cl	78	1,290	491	417
NO_3	18.3	433	166	145
HCO_3	20.2	412	204	105
SO_4	2.9	527.4	139	158

WHO Standards	
Cl	NO3
250	45

Correlation Coefficients

Table 3 Correlation coefficient of the chemical parameters

	F	Ca	Alk	TDS	EC	Mg	Na	K	Cl	NO_3	HCO_3	SO_4
F	1											
Sign.	–											
Ca	0.224	1										
Sign.	0.212	–										
Alk	0.284	**0.918**	1									
Sign.	0.152	0	–									
Sign.	0	0.28	0.183									
TDS	0.416	**0.583**	**0.642**	1								
Sign.	0.062	0.011	0.005	–								
EC	0.406	**0.585**	**0.625**	**0.998**	1							
Sign.	0.066	0.011	0.006	0	–							
Mg	0.228	**0.841**	**0.887**	**0.795**	**0.797**	1						
Sign.	0.207	0	0	0	0	–						
Na	0.407	0.314	0.412	**0.95**	**0.947**	**0.615**	1					
Sign.	0.066	0.127	0.064	0	0	0.007	–					
K	**0.546**	**0.649**	**0.657**	**0.899**	**0.899**	**0.753**	**0.826**	1				
Sign.	0.018	0.004	0.004	0	0	0.001	0	–				
Cl	**0.434**	0.429	0.509	**0.969**	**0.968**	**0.708**	**0.981**	**0.885**	1			
Sign.	0.053	0.055	0.026	0	0	0.002	0	0	–			
NO_3	−0.078	**0.891**	**0.778**	0.352	0.355	**0.673**	0.075	0.34	0.151	1		
Sign.	0.391	0	0	0.099	0.097	0.003	0.395	0.108	0.296	–		
HCO_3	**0.495**	**0.613**	**0.691**	**0.788**	**0.783**	**0.744**	**0.66**	**0.707**	**0.658**	**0.467**	1	
Sign.	0.03	0.008	0.002	0	0	0.001	0.004	0.002	0.004	0.04	–	
SO_4	0.405	0.211	0.298	**0.88**	**0.879**	**0.495**	**0.932**	**0.702**	**0.905**	−0.045	0.642	1
Sign.	0.067	0.225	0.141	0	0	0.03	0	0.002	0	0.437	0.005	–

Significant correlation between NO3 and Ca believed to be caused by wastewater contamination interacting with calcite.

Previous paper showed little correlation between NO3 and Ca, strong positive correlation between NO3 and Na, K, Mg, Cl, and SO4

My Input

```
------------------------------------
Reading input data for simulation 1.
------------------------------------

        TITLE Average
        SOLUTION 1
                pH 7.9
                temp 25
                pe
                units mg/L
                Alkalinity 365
                Ca 70
                Cl 491
                F 1.25
                K 4.21
                Mg 41
                N 166 as N03-
                Na 325
                S 139 as SO4-2
        END
```

```
------------------------------------
Reading input data for simulation 1.
------------------------------------

        TITLE Increased NO3
        SOLUTION 1
                pH 7.9
                temp 25
                pe
                units mg/L
                Alkalinity 365
                Ca 70
                Cl 491
                F 1.25
                K 4.21
                Mg 41
                N 5000 as N03-
                Na 325
                S 139 as SO4-2
        END
```

Percent/Molality Increases

Species	% Increase	Molality Increase
Ca	.515%	9e-06
Na	.494%	7e-05
K	.557%	6e-07
Mg	.474%	8e-06
Cl	.505%	7e-05
SO4	.483%	7e-06

My results indicate that the earlier paper was right in noting that Na, K, Mg, Cl, and SO4 were positively correlated with NO3 due to wastewater pollution, while the newer paper was right in finding a positive correlation between NO3 and Ca due to interactions between wastewater and calcite.

Future Studies

- I was unable to include TDS and EC in my models, which could have affected the results.
- It's important to determine which paper is correct about the correlations between ions so that people trying to address the pollution have a better understanding of how to attack the problem. Future studies should work on figuring out why these two studies came to such different conclusions about how wastewater is interacting with the environment.

References

- Al-Agha, M. R. (2005). Hydrogeochemistry and carbonate saturation model of groundwater, Khanyounis Governorate—Gaza Strip, Palestine. *Environmental Geology*, *47*(7), 898-906.
- Burg, A., & Heaton, T. H. (1998). The relationship between the nitrate concentration and hydrology of a small chalk spring; Israel. *Journal of hydrology*, *204*(1), 68-82.