

Groundwater Quality in the Mazar-i-Sharif city, North Afghanistan

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NDSU Geochemistry 2018

Location

- Mazar-I-Sharif city is in the Balkh province in northern Afghanistan



Background

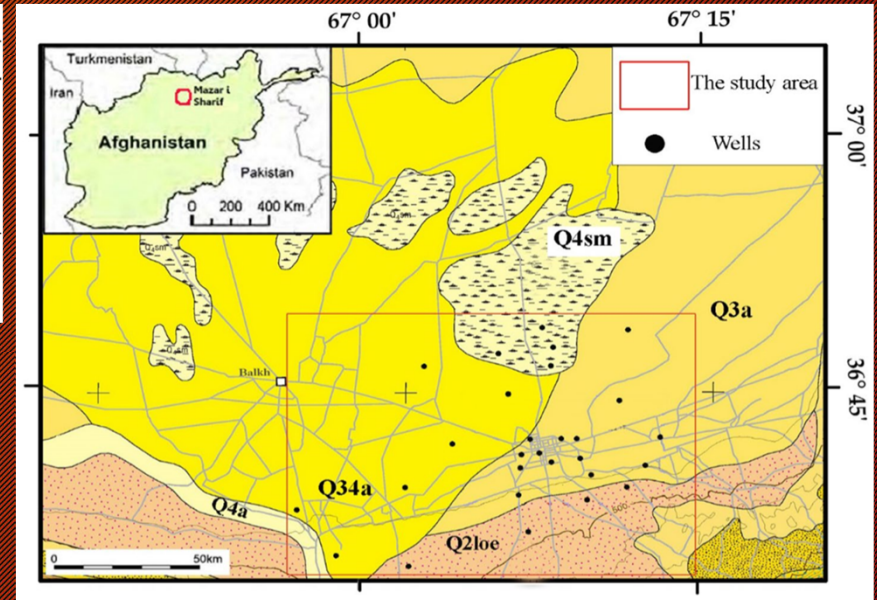
- Main land use is agriculture
- All previous geologic and hydrogeology work has been lost in the prolonged wars
- First look into the chemistry of the water
- Mazar-i-sharif is situated in the Northern Afghanistan Basin (NAB)
- Two main water sources, shallow aquifer and the Nahri-Shahi stream

Regional Geology

- Mazar-i-sharif is situated in the Northern Afghanistan Basin (NAB)

Table 1 Geological units and their characteristics in the study area

Geological unit	Characteristics	Age
Q4a	Conglomerate and sandstone; alluvium, detrital sediments, gravel and sands	Holocene
Q4sm	Mud, silt, clay, more abundant than sand; limestone, gypsum, and salt	Holocene
Q34a	Conglomerate and sandstone; alluvium, detrital sediments, gravel and sands	Holocene—late Pleistocene
Q3a	Conglomerate and sandstone; detrital sediments, gravel and sands	Late Pleistocene
Q2loe	Loess; loess content more than sand and clay	Middle Pleistocene



Problems

- Water deficiency
- No prior work done in the area on water chemistry
- 27% of the measured values meet the WHO classification while the rest exceed their limits

Previous Work

Parameter	Min	Max	Mean	Guideline values WHO (2011)
pH	6.6	8.4	7.7	6.5–8.5
EC ($\mu\text{S}/\text{cm}$)	1003	6235	3495	1500
TDS (mg l^{-1})	667	4021	2310	1000
Ca^{2+} (mg l^{-1})	57	293	161	200
Mg^{2+} (mg l^{-1})	34	199	78	150
Na^+ (mg l^{-1})	71	1120	471	200
K^+ (mg l^{-1})	1.13	32	11	20
HCO_3^- (mg l^{-1})	207	1493	479	240
Cl^- (mg l^{-1})	119	1607	637	250
SO_4^{2-} (mg l^{-1})	119	1254	490	250
NO_3^- (mg l^{-1})	42	96	59	50
CO_3^{2-}	0	52	10	–
F^-	0.009	0.063	0.026	1.5
TH	327	1719	724	–
SAR	1.3	19.1	7.6	–
%Na	26	81	55	–
RSC	–32.4	5.5	–6.46	–
PI	43	84	63.7	–
SI calcite	–1.08	1.51	0.35	–
SI dolomite	–0.73	2.95	0.85	–
SI gypsum	–3.52	–0.32	–1.17	–
SI anhydrate	–3.27	–0.51	–1.34	–

- Na^+ primarily comes from cation exchange within minerals
- Mg^{2+} comes from ion exchange in minerals
- Ca^{2+} comes from calcium rich rock, Calcite, Dolomite, and Gypsum
- CO_3^{2-} and HCO_3^- come from weathering of carbonates and dissolution of carbonic acid
- High values of SO_4^{2-} in groundwater indicated that SO_4^{2-} derived from chemical fertilizers

Focus for PHREEQC

- Attempt to limit two or more of the super saturated solvents to meet the WHO guidelines for a healthy drinking water.
- Which two solvents to remove
- Na^+ and Cl^-
- Removing one of the constituents at a time
- Using the Solution Master Species database

1st Simulation

SOLUTION 1

```

temp      25
pH        7.7
pe         4
redox     pe
units     mg/l
density   1
Ca        161
Cl        637
F         0.026
N(5)      59
K         11
Mg        78
S(6)      490
Na        471
C(4)      10
-water    1 # kg
  
```

-----Saturation indices-----

Phase	SI**	log IAP	log K(298 K,	1 atm)
Anhydrite	-1.18	-5.54	-4.36	CaSO ₄
Aragonite	-1.02	-9.32	-8.30	CaCO ₃
Artinite	-6.48	3.12	9.60	MgCO ₃ :Mg(OH) ₂ :3H ₂ O
Brucite	-4.32	12.52	16.84	Mg(OH) ₂
Calcite	-0.84	-9.32	-8.48	CaCO ₃
CH ₄ (g)	-74.48	-115.52	-41.05	CH ₄
CO ₂ (g)	-3.78	-21.92	-18.15	CO ₂
Dolomite(disordered)	-2.18	-18.72	-16.54	CaMg(CO ₃) ₂
Dolomite(ordered)	-1.63	-18.72	-17.09	CaMg(CO ₃) ₂
Epsomite	-3.49	-5.62	-2.13	MgSO ₄ :7H ₂ O
Fluorite	-4.32	-14.82	-10.50	CaF ₂
Gypsum	-0.93	-5.54	-4.61	CaSO ₄ :2H ₂ O
Halite	-5.20	-3.60	1.60	NaCl
Huntite	-7.56	-37.53	-29.97	CaMg ₃ (CO ₃) ₄
Hydromagnesite	-16.32	-25.08	-8.77	Mg ₅ (CO ₃) ₄ (OH) ₂ :4H ₂ O
Lime	-20.10	12.60	32.70	CaO
Magnesite	-1.94	-9.40	-7.46	MgCO ₃
Mg(OH) ₂ (active)	-6.27	12.52	18.79	Mg(OH) ₂
MgF ₂	-6.77	-14.90	-8.13	MgF ₂
Mirabilite	-5.17	-6.29	-1.11	Na ₂ SO ₄ :10H ₂ O
Natron	-8.76	-10.07	-1.31	Na ₂ CO ₃ :10H ₂ O
Nesquehonite	-4.73	-9.40	-4.67	MgCO ₃ :3H ₂ O
O ₂ (g)	-36.29	46.80	83.09	O ₂
Periclase	-9.06	12.52	21.58	MgO
Portlandite	-10.20	12.60	22.80	Ca(OH) ₂
Thenardite	-6.60	-6.28	0.32	Na ₂ SO ₄
Thermonatrite	-10.71	-10.07	0.64	Na ₂ CO ₃ :H ₂ O

2nd Simulation

SOLUTION 1

```

temp      25
pH         7.7
pe         4
redox     pe
units     mg/l
density   1
Ca        161
Cl        110000
F         0.026
N(5)      59
K         11
Mg        78
S(6)      490
Na        80000
C(4)      10
-water    1 # kg
  
```

```

-----Saturation indices-----
Phase      SI** log IAP  log K(298 K,  1 atm)
Anhydrite  -1.45   -5.81   -4.36  CaSO4
Aragonite  -0.62   -8.92   -8.30  CaCO3
Artinite   -4.46    5.14    9.60  MgCO3:Mg(OH)2:3H2O
Brucite    -2.92   13.93   16.84  Mg(OH)2
Calcite    -0.44   -8.92   -8.48  CaCO3
CH4(g)     -75.01  -116.06 -41.05  CH4
CO2(g)     -4.44   -22.59  -18.15  CO2
Dolomite(disordered) -0.98   -17.52  -16.54  CaMg(CO3)2
Dolomite(ordered)  -0.43   -17.52  -17.09  CaMg(CO3)2
Epsomite   -3.81   -5.94   -2.13  MgSO4:7H2O
Fluorite   -5.09  -15.59  -10.50  CaF2
Gypsum     -1.33   -5.94   -4.61  CaSO4:2H2O
Halite      0.18    1.78    1.60  NaCl
Huntite    -4.75  -34.71  -29.97  CaMg3(CO3)4
Hydromagnesite -11.95  -20.72   -8.77  Mg5(CO3)4(OH)2:4H2O
Lime       -19.04   13.66   32.70  CaO
Magnesite  -1.14   -8.60   -7.46  MgCO3
Mg(OH)2(active) -4.87   13.93   18.79  Mg(OH)2
MgF2       -7.13  -15.26   -8.13  MgF2
Mirabilite -1.84   -2.96   -1.11  Na2SO4:10H2O
Natron     -4.76   -6.07   -1.31  Na2CO3:10H2O
Nesquehonite -4.12   -8.79   -4.67  MgCO3:3H2O
O2(g)     -36.42   46.67   83.09  O2
Periclase  -7.59   13.99   21.58  MgO
Portlandite -9.20   13.60   22.80  Ca(OH)2
Thenardite -2.63   -2.31    0.32  Na2SO4
Thermonatrite -6.12   -5.49    0.64  Na2CO3:H2O
  
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Discussion

- To make the Na^+ and Cl^- at or below values set by the WHO the amount of Na^+ and Cl^- needed is extreme and further complicates the water quality.
- How to lower concentrations?
- What inputs meet this requirements?

References

- Mahaqi, Ali , et al. “Hydrogeochemical Characteristics and Groundwater Quality Assessment for Drinking and Irrigation Purposes in the Mazar-i-Sharif City, North Afghanistan.” *Applied Water Science*, 6 Aug. 2018.
- Google Earth

Questions?

