XVIII World Water Congress
International Water Resources Association (IWRA)

Assessing the vulnerability of coastal groundwater quality to climate change impacts in Cape Coast, Ghana

Joseph Zume

Geography and Earth Science, Shippensburg University of Pennsylvania

&

Simon Mariwah

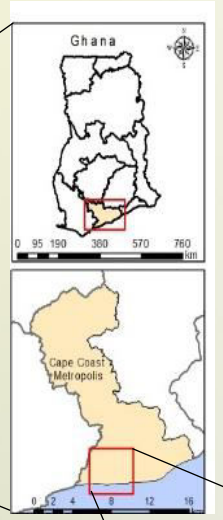
Department of Geography and Regional Planning, University of Cape Coast, Ghana

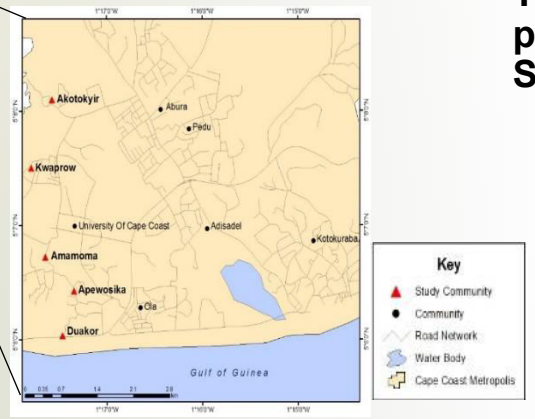
XVIII WORLD WATER CONGRESS
Water for All
Harmony between Humans and Nature
第18届 世界水资源大会
水与万物:
人与自然和谐共生

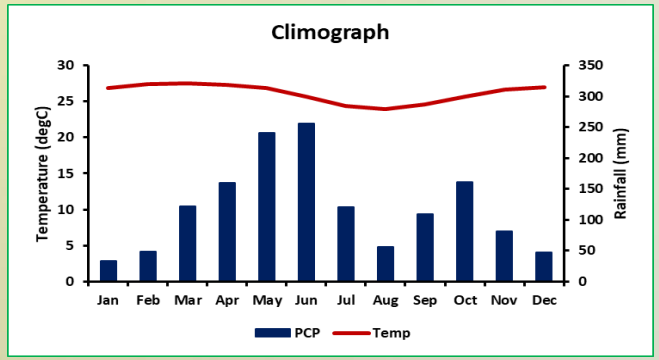
The Study Area

Cape Coast, Ghana

XVIII World Water Congress
International Water Resources Association (IWRA)







Climate

- **Located in the central region of Ghana.**
- **Population of roughly 200,000 people.**

BACKGROUND

- **Two critical challenges are common in peri-urban neighborhoods of most Sub-Saharan African cities:**

(1) Poor access to good quality drinking water

(2) Lack of access to improved sanitation facilities

In Ghana, about 67% of the total population lacks access to improved sanitation facilities and 70% of diseases in the country are water-borne.

The Problem

Poor city drainage s

Increasing floods

Onsite sanitation

Defining vulnerability

Data collection and processing

XVIII World Water Congress
International Water Resources Association (IWRA)

Stage 1: IN-SITU measurements

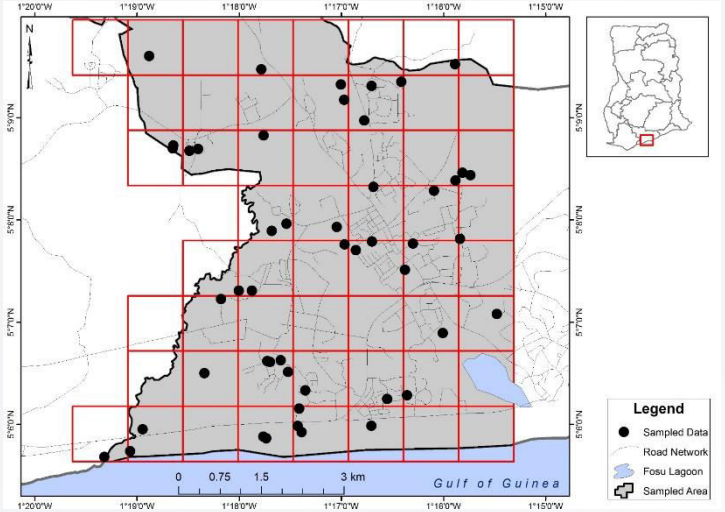
in-situ

(151 wells, 4 river, and 4 sea samples)

- DTW in wells
- Well-to-septic system distances
- Electrical conductivity
- Total dissolved solids (TDS)
- Salinity
- Sampled soils and tested for characteristics
- Assessment of sanitation infrastructure

Stage 2: LAB ANALYSES

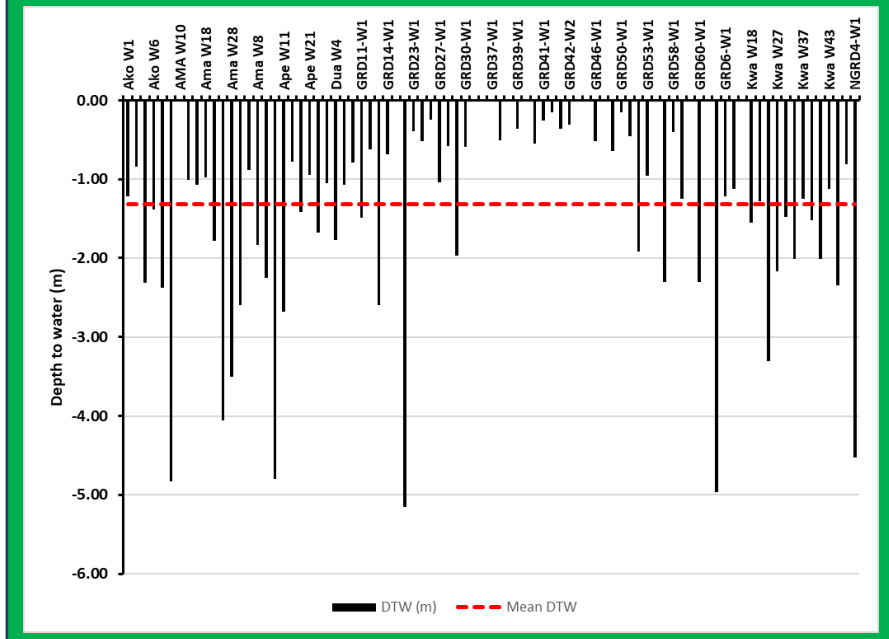
- Water samples assessed for:
  - Enteric bacteria
  - Water chemistry
    - Cations (Na, K, Ca, Mg, etc.)
    - Anions (Cl, Br, SO4, HCO3, NO3, PO4, F, etc.)



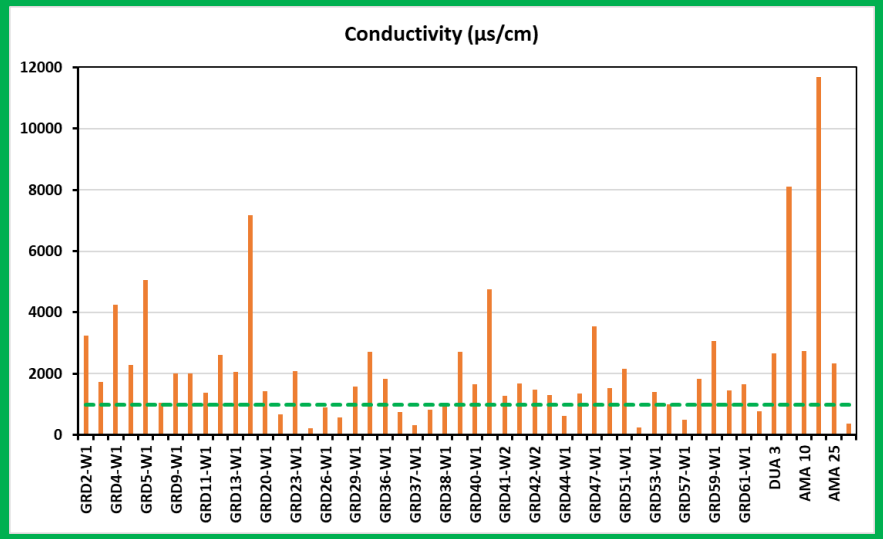
Precipitation and temperature analyses (ongoing)

Results

Depth to water (DTW) in wells



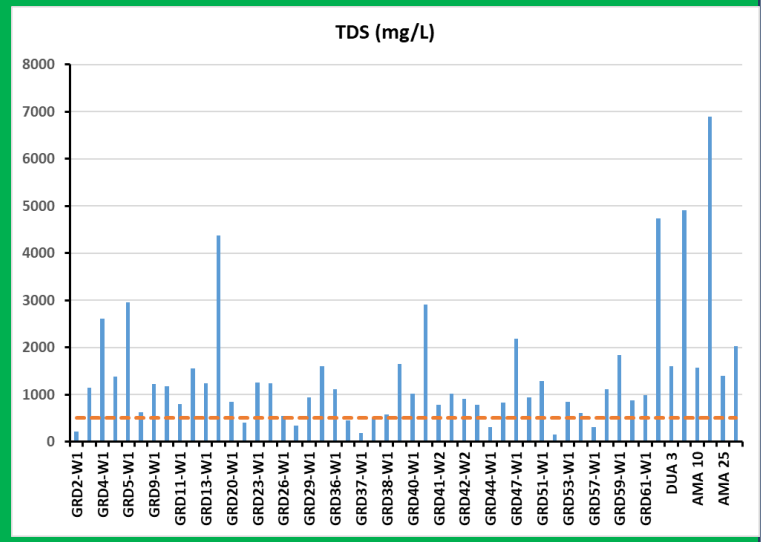
Shallow water tables. Average DTW is 1.32 m. About 87% of the wells have DTW of less than 2.5 m, the average depth of septic tanks.



Mean conductivity = 2,186 µS/cm
Maximum = 11,680 µS/cm
Minimum = 223 µS/cm

(63%) > 1500 µS/cm

Measured sea value = 53,500 µS/cm



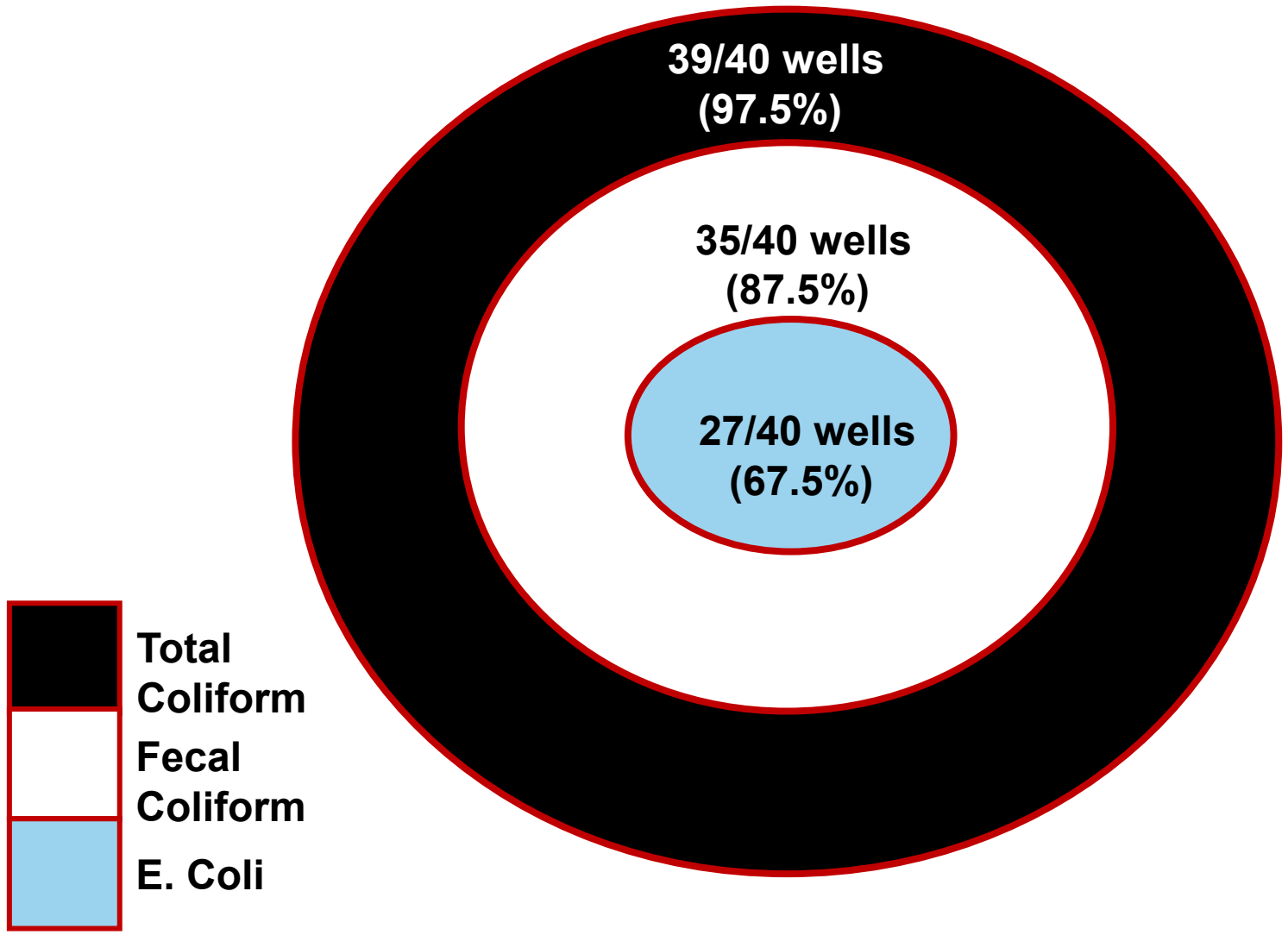
Mean TDS = 1,419 mg/L)
Maximum = 6,900 mg/L
Minimum = 150 mg/L

WHO threshold: 500 mg/L

77% > 500 mg/L

Measured sea value = 31,970 mg/L

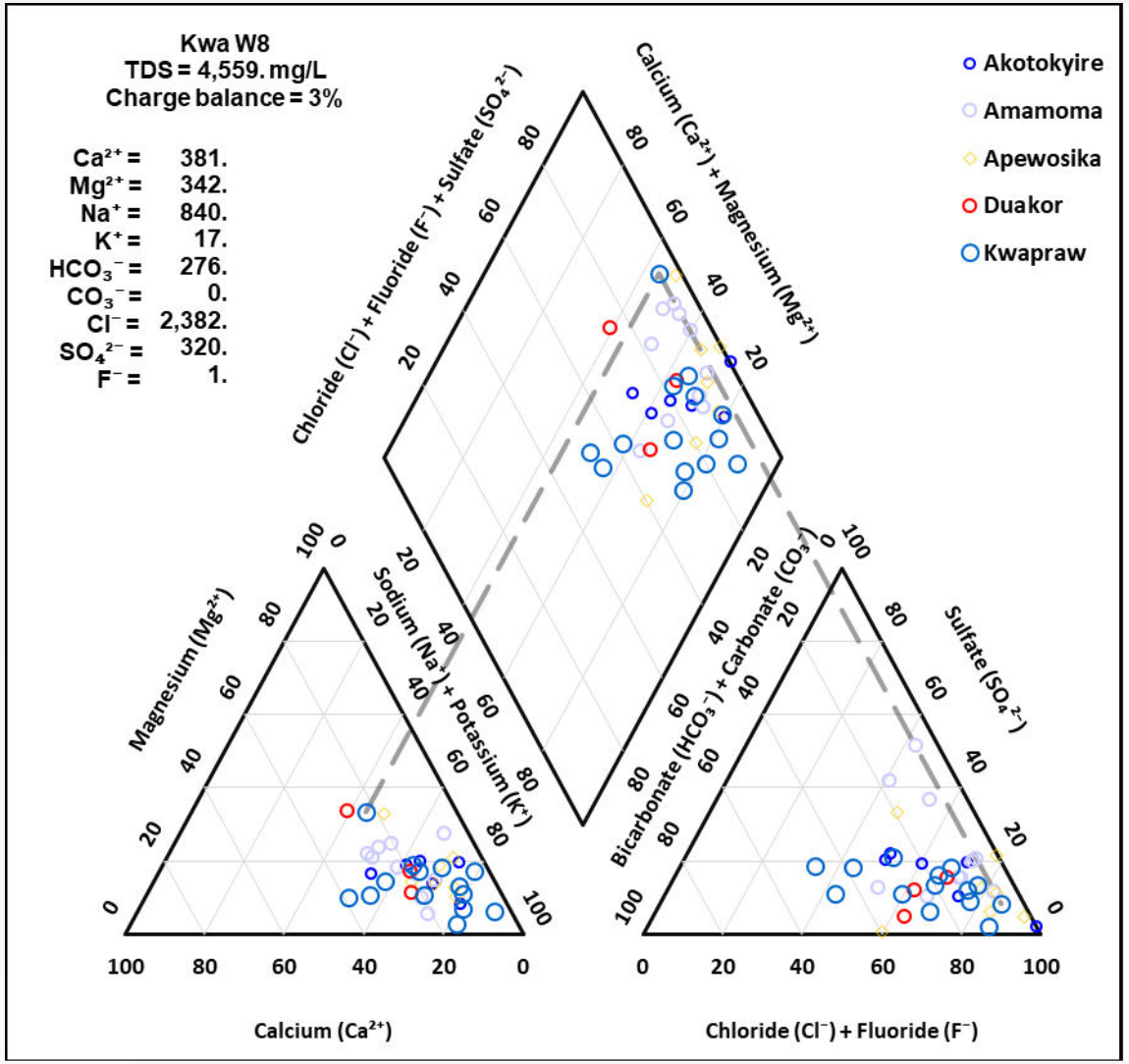
Microbial results



WHO threshold
(zero count)

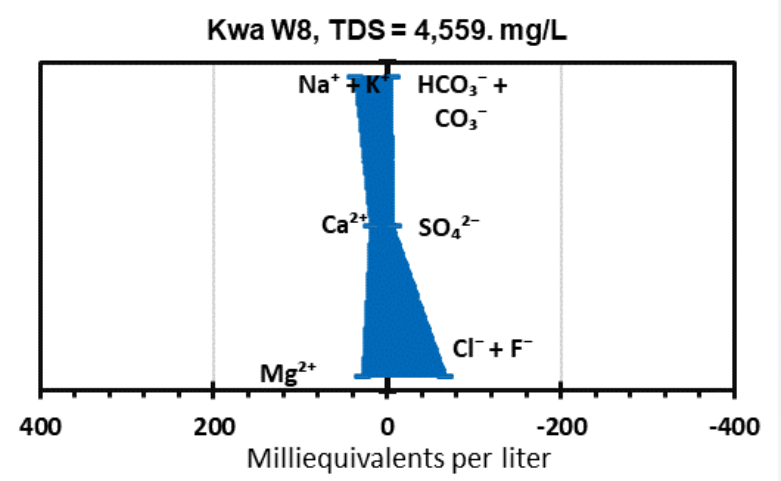
Hydrochemical facies

XVIII World Water Congress
International Water Resources Association (IWRA)

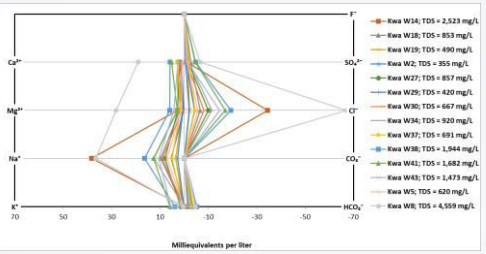


Piper diagram

Stiff diagram

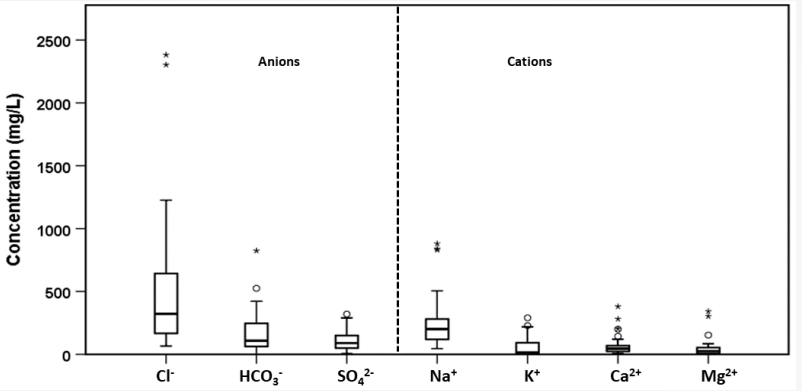


Diagnostic Stiff diagram



Dominant water type

- **Sodium chloride**



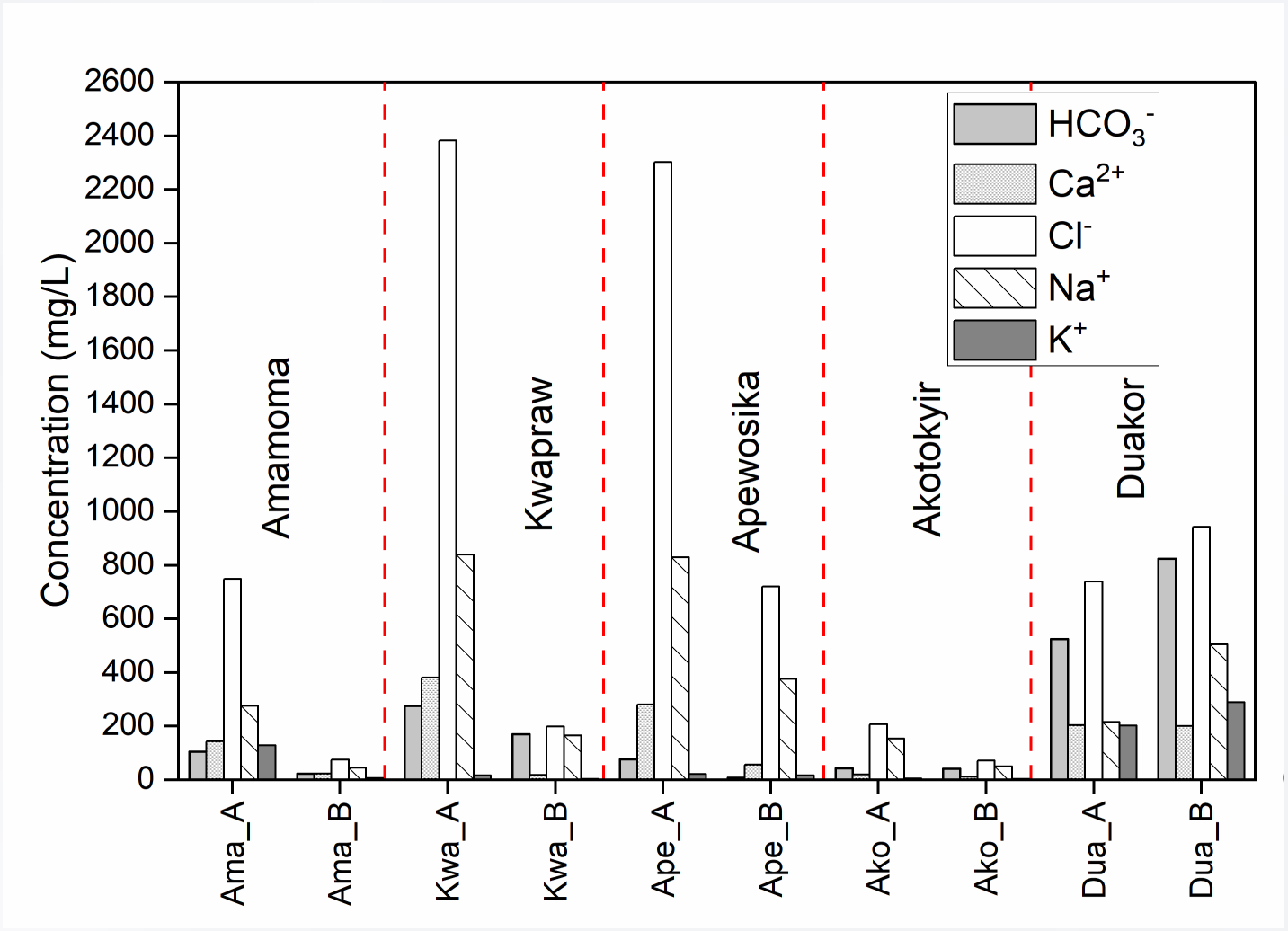
Dominant Cations

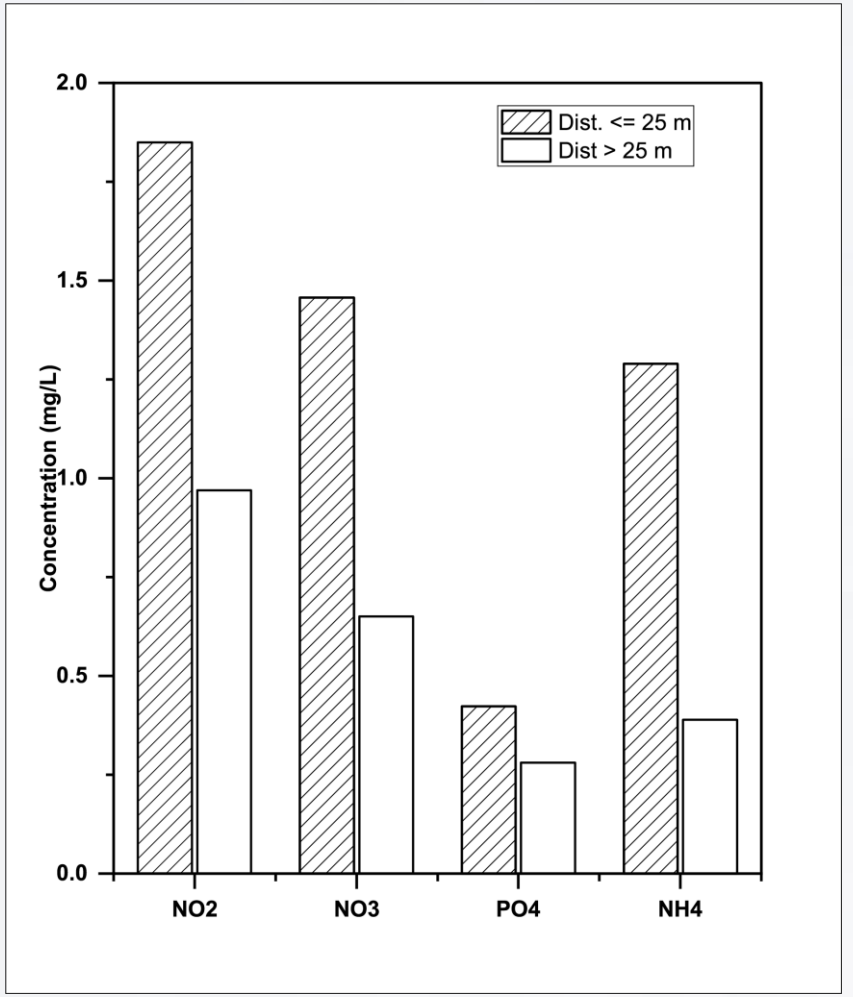
- Sodium and potassium

Dominant Anions

- Chloride and bicarbonate

Effects of on-site sanitation





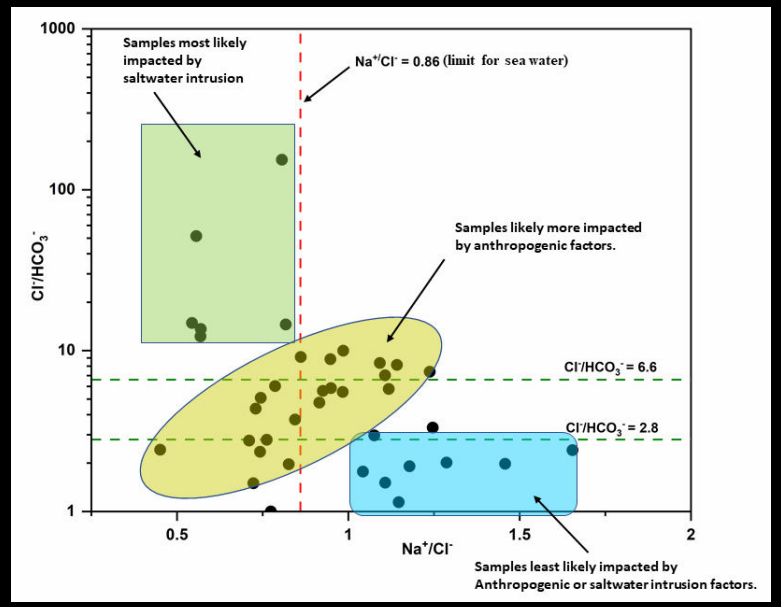
Well location within 25 m vs. beyond

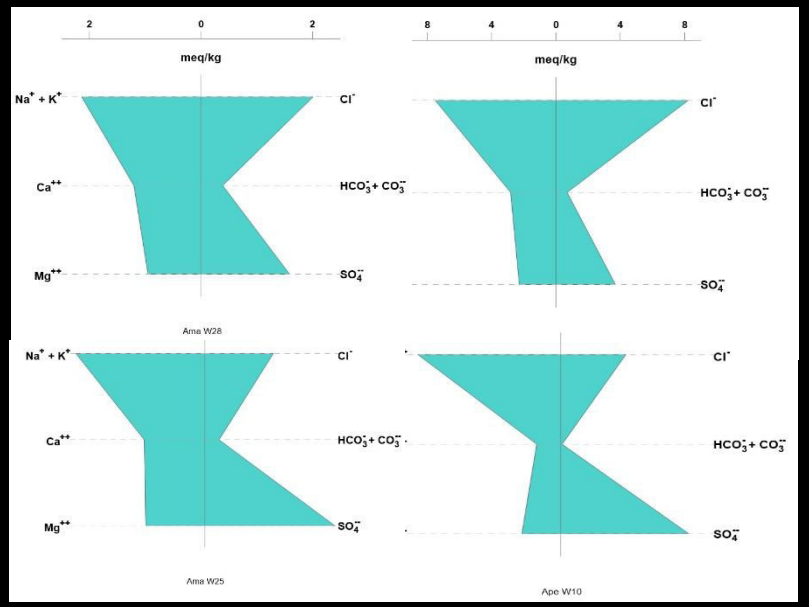
There is evidence of sanitation-related groundwater contamination.

Effects of saltwater intrusion

- Cl^- ion classification
- Cl/Br
- Na/Cl
- Mg/Ca
- SO4/Cl
- K/Cl
- Cl/HCO_3
- Bex

Sample ID	Ca++ meq/l	Mg++ meq/l	Na+ meq/l	K+ meq/l	HCO3- meq/l	SO4-- meq/l	Cl- meq/l	F- meq/l	Br- meq/l	Cl/Br	Mg/Ca	Na/Cl	SO4/Cl	K/Cl	Cl/HCO3	BEX
KR	1.046	0.06089	1.141	0.2056	1.442	3.331	0.9164	0.005263	0.07325	12.51	0.06	1.25	3.63	0.22	0.64	0.43
G1	1.875	2.691	3.708	0.4113	3.504	0	2.481	0.027895	0.0125	198.48	1.44	1.49	0.00	0.17	0.71	4.15
G3	2.093	1.522	2.281	2.261	7.604	4.997	0.8882	0.034211	0.053375	16.64	0.73	2.57	5.63	2.55	0.12	5.11
G4	1.591	3.325	4.278	1.234	1.541	4.164	2.735	0.041579	0.06925	39.49	2.09	1.56	1.52	0.45	1.77	5.91
NG4	1.569	1.293	2.567	0.6167	2.458	0.8328	1.325	0.042632	0.005625	235.56	0.82	1.94	0.63	0.47	0.54	3.06
G5	2.572	5.534	4.564	3.29	17.63	9.161	2.425	0.049474	0.055625	43.60	2.15	1.88	3.78	1.36	0.14	10.79

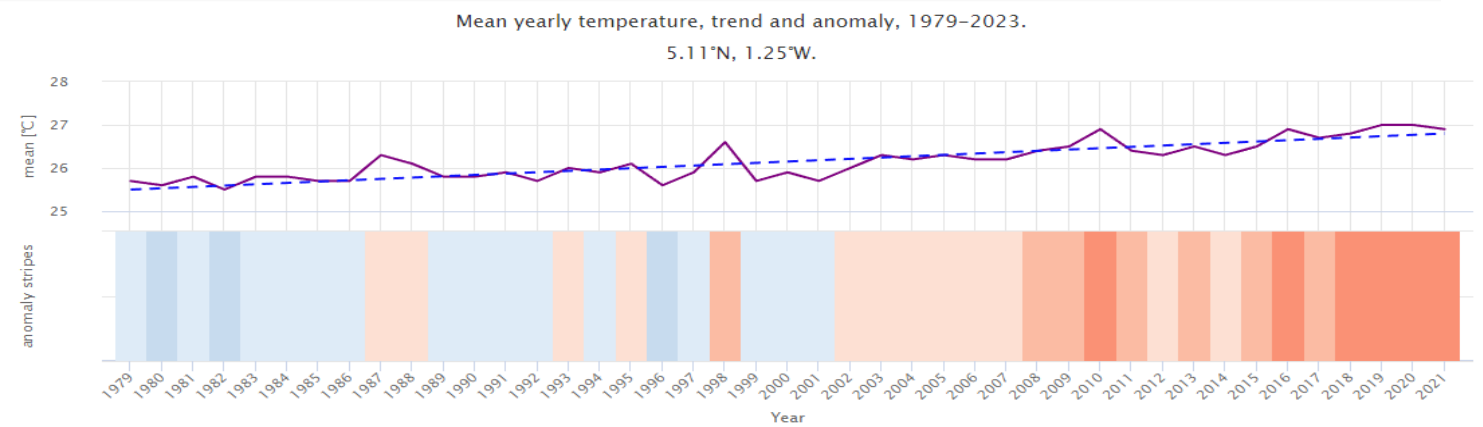




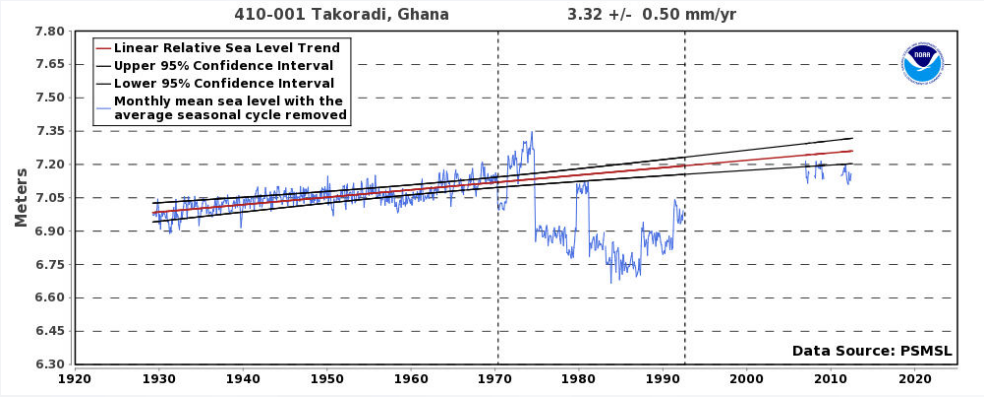
Stiff diagrams

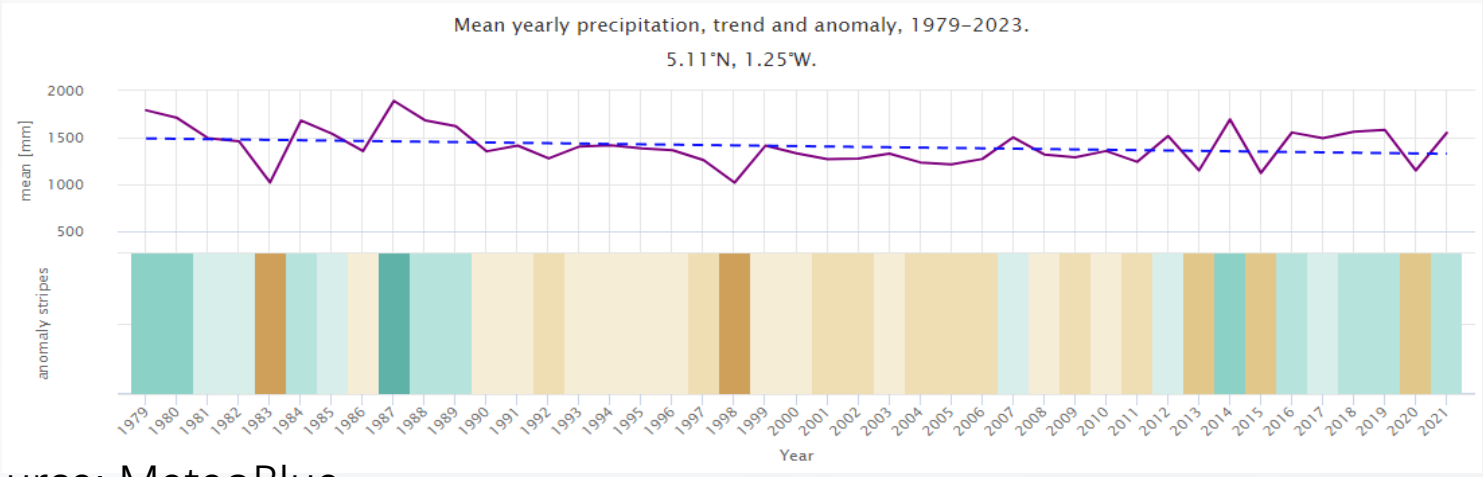
There is evidence of saltwater intrusion into groundwater wells.

Potential climate change effects

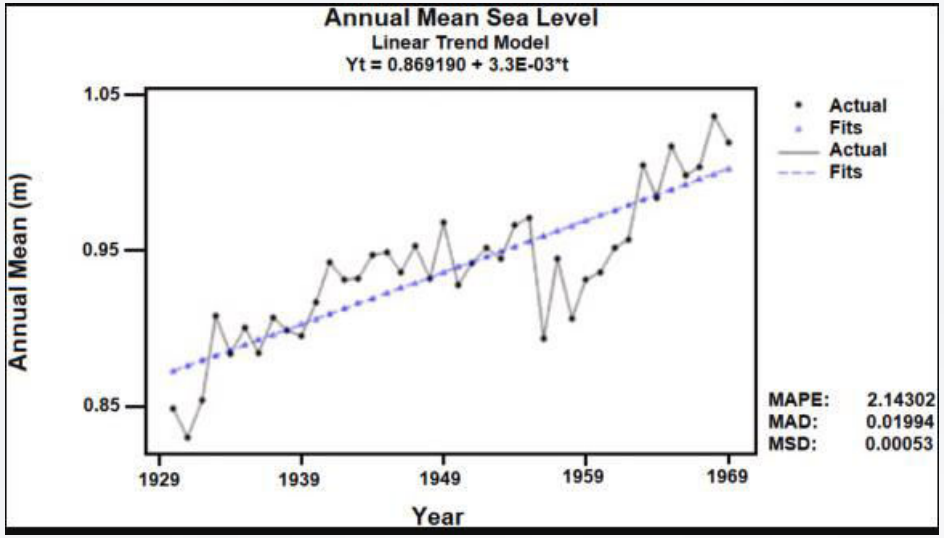


Temperature trend





Precipitation trend



Source: MeteoBlue

Source: Avornyo et al. (2023)

Conclusions

- There is widespread contamination of groundwater wells with fecal bacteria and solutes in domestic wells.
  - due to onsite sanitation and saltwater intrusion.
- Saltwater may have intruded for about 2 km inland.
- We are still analyzing temperature and precipitation data, but:
  - The increasing temperatures
  - Increasing floods
  - Poor drainage systems, and
  - Onsite sanitation
- are recipes for exacerbated climate change impacts on groundwater quality in the study area.