4th SADC GROUNDWATER CONFERENCE
10th -12th of November 2021
VIRTUAL CONFERENCE

GROUNDWATER MANAGEMENT INSTITUTE

- ELY LEBURU

PROF LOBINA PALAMULENI

Hydrochemical assessment of groundwater quality of the Grootfontein aquifer, North West province, South Africa

BACKGROUND

- Groundwater forms part of the dynamic system referred to as the hydrological cycle and forms an important source of water supply globally.
- The groundwater resource can be explained in various ways; according to its location, occurrence in time, characteristics, accessibility measures, size, and measures taken to harness it consistent with its demand
- Studies agree that, due to water demand for drinking, irrigation and industrialization, groundwater has become an important commodity. (Nas & Berktay, 2010, Singh *et al.*, 2011, Logeshkumaran *et al.*, 2015)

AIM

- The aim of this study was to investigate the hydrochemistry of the Grootfontein aquifer in the North West province, South Africa.

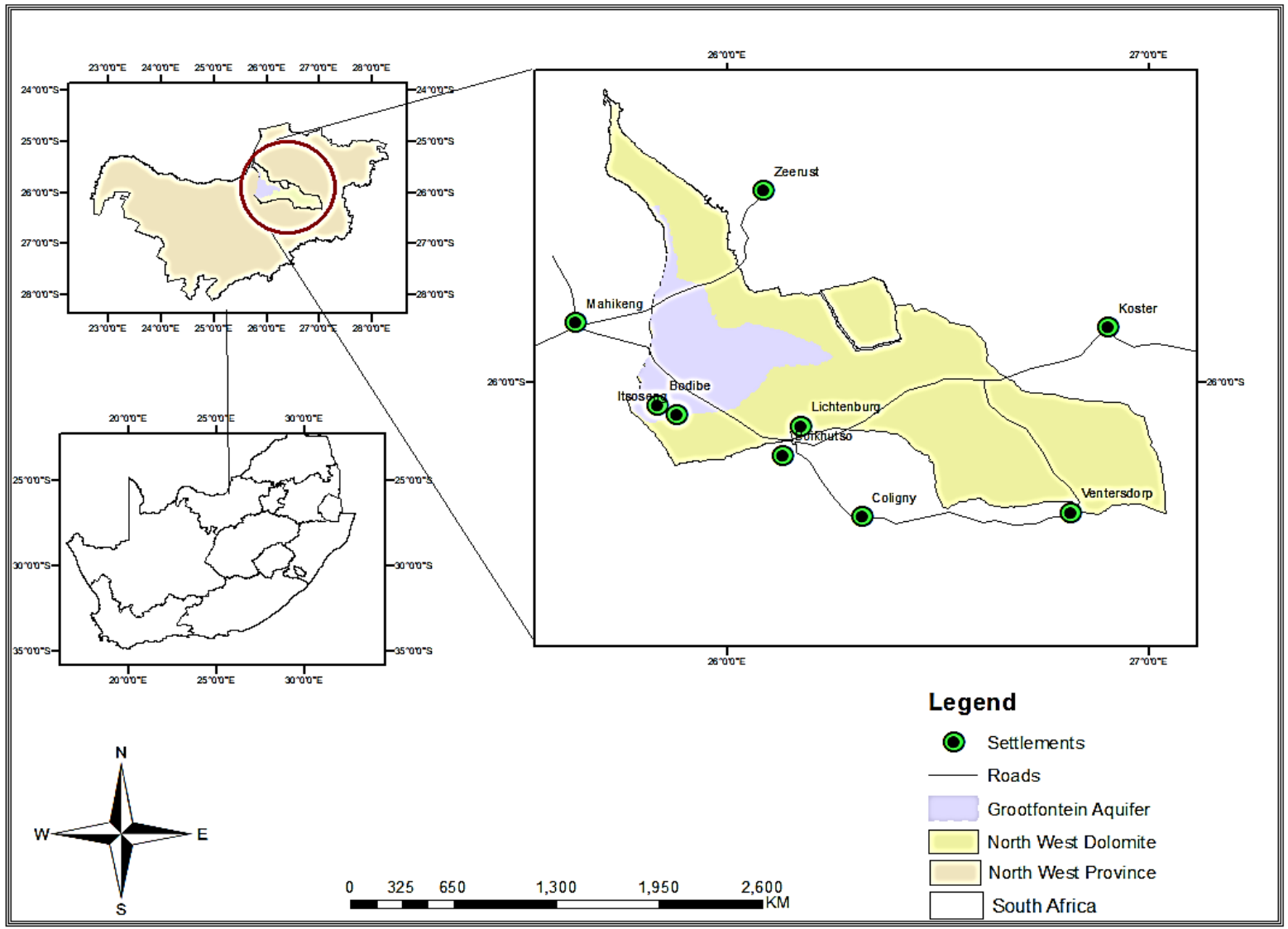
OBJECTIVES

- To determine the physio-chemical concentration of groundwater quality parameters,
- To assess distribution of the major cations and anions.

Justification of the study

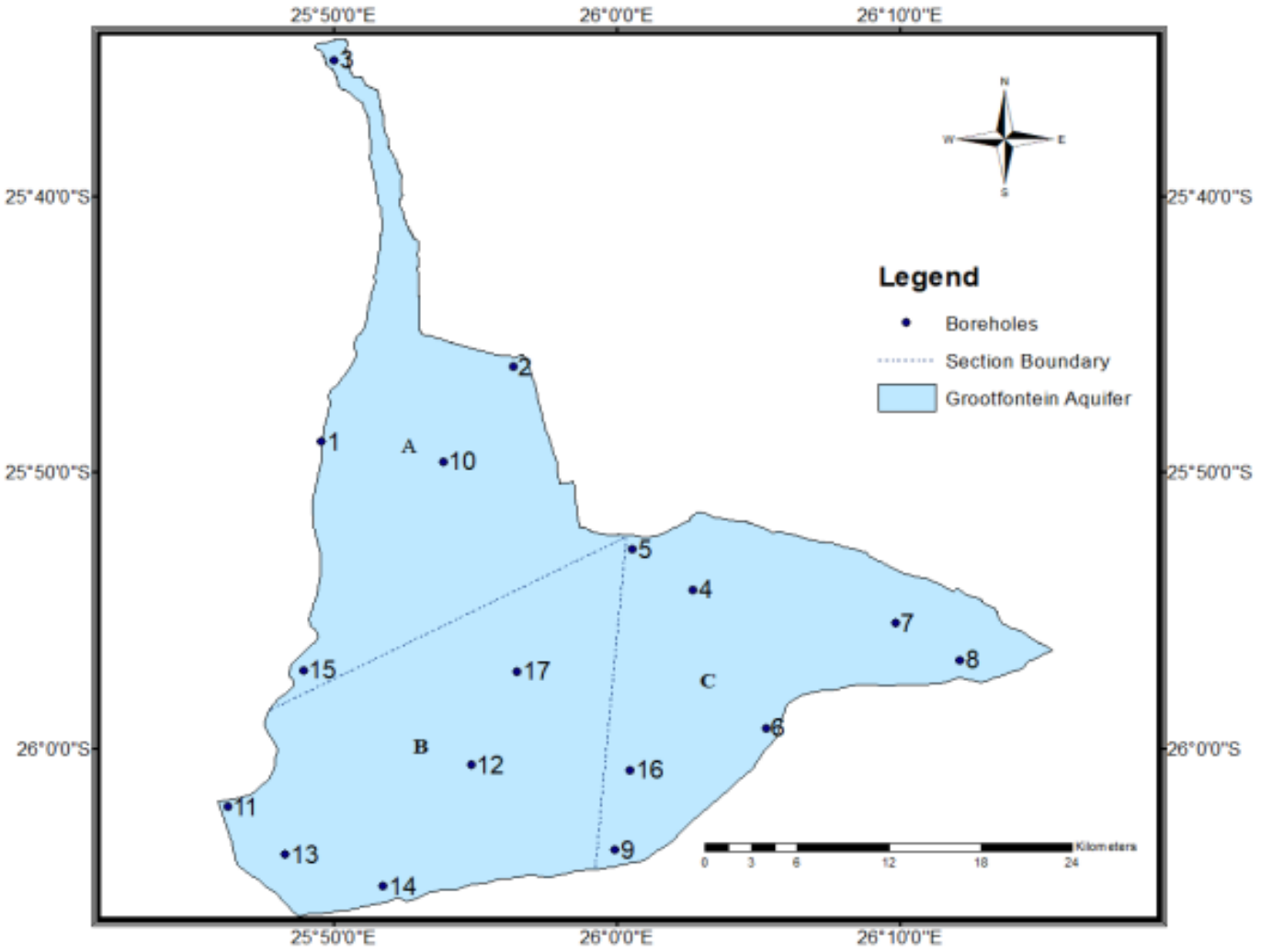
- Understanding of groundwater for sustainability and pollution protection
- Health to human and in crop irrigation

STUDY AREA AND THE NORTH WEST DOLOMITE

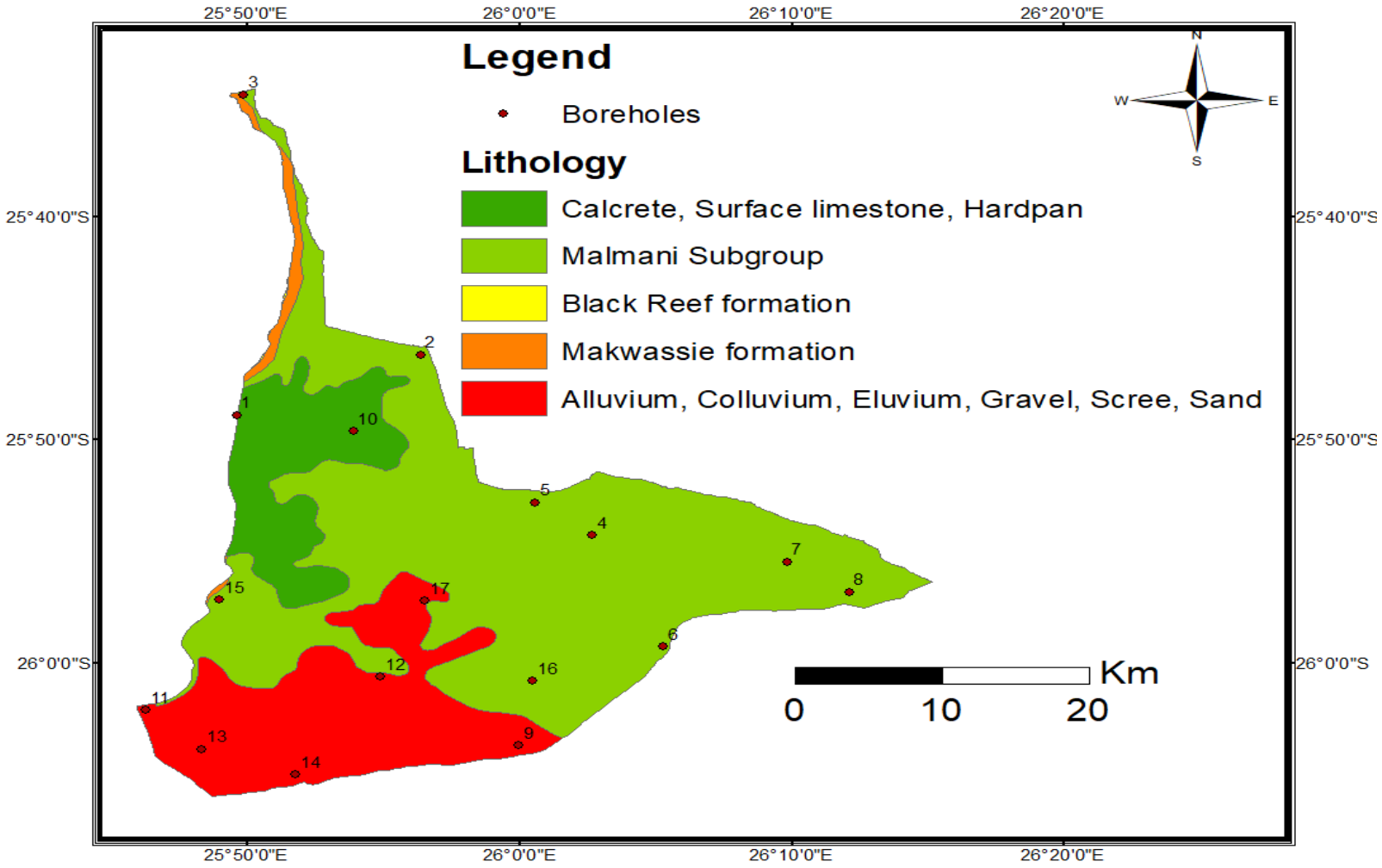


Dependent Towns include:
Zeerust
Litchtenburg
Ventersdorp
Koster
Coligny
Mafikeng

The study Area



ROCK COMPOSITION OF THE STUDY AREA



METHODOLOGY

Data analysis

1. In situ data analysis

The hydrogen ionic concentration (pH), temperature, electrical conductivity (EC) as well as total dissolved solids (TDS) were all immediately measured on site following sampling using MM 40+ CRISION portable metre. This instrument was calibrated according to owner's manual prior to usage.

2. Laboratory data analysis

- The major ions were analysed in the laboratory using the inductively coupled plasmer mass spectrometry (ICP-MS) applying a total quant method.
- Sulphate (SO^{2-}_4) was obtained using the oxidation equation. Concentration of bicarbonate (HCO^{-}_3) ion was obtained by using the Henderson-Hasselbalch equation as follows:

$$HCO_3^- = 0.03 \times 10^{pH-6.1}$$

While Nitrate (NO^{-}_3) ions were obtained by

$$NO_3^- = N \times 4.44$$

The total hardness (TH) was obtained by using the calcium (Ca^{2+}) and magnesium (Mg^{2+}) concentrations (mg/L) as

$$TH = 2.497 \times (Ca^{2+}) + 4.115 \times (Mg^{2+})$$

RESULTS

Summary of physical parameters of groundwater

Parameters	units	SAWQG standards		WHO standards		Minimum	Maximum	Average	SD
		Most desirable	Maximum allowable	Most desirable	Maximum allowable				
T	°C	15.50	25.0	18	25-37.2	16.00	25.60	20.06	2.88
TDS	mg/l	<250	100-450	<300	100-500	253.00	692.00	430.79	129.95
EC	µS/m	<70	100-200	<200	180-500	395.50	944.00	593.21	159.56
pH		6.0-9.0	6.0-9.0	.5-8.5	6.5-8.5	6.34	8.44	7.82	0.44
TH	mg/L	<50	100-250	<100	100-500	14.61	166.95	95.84	46.32

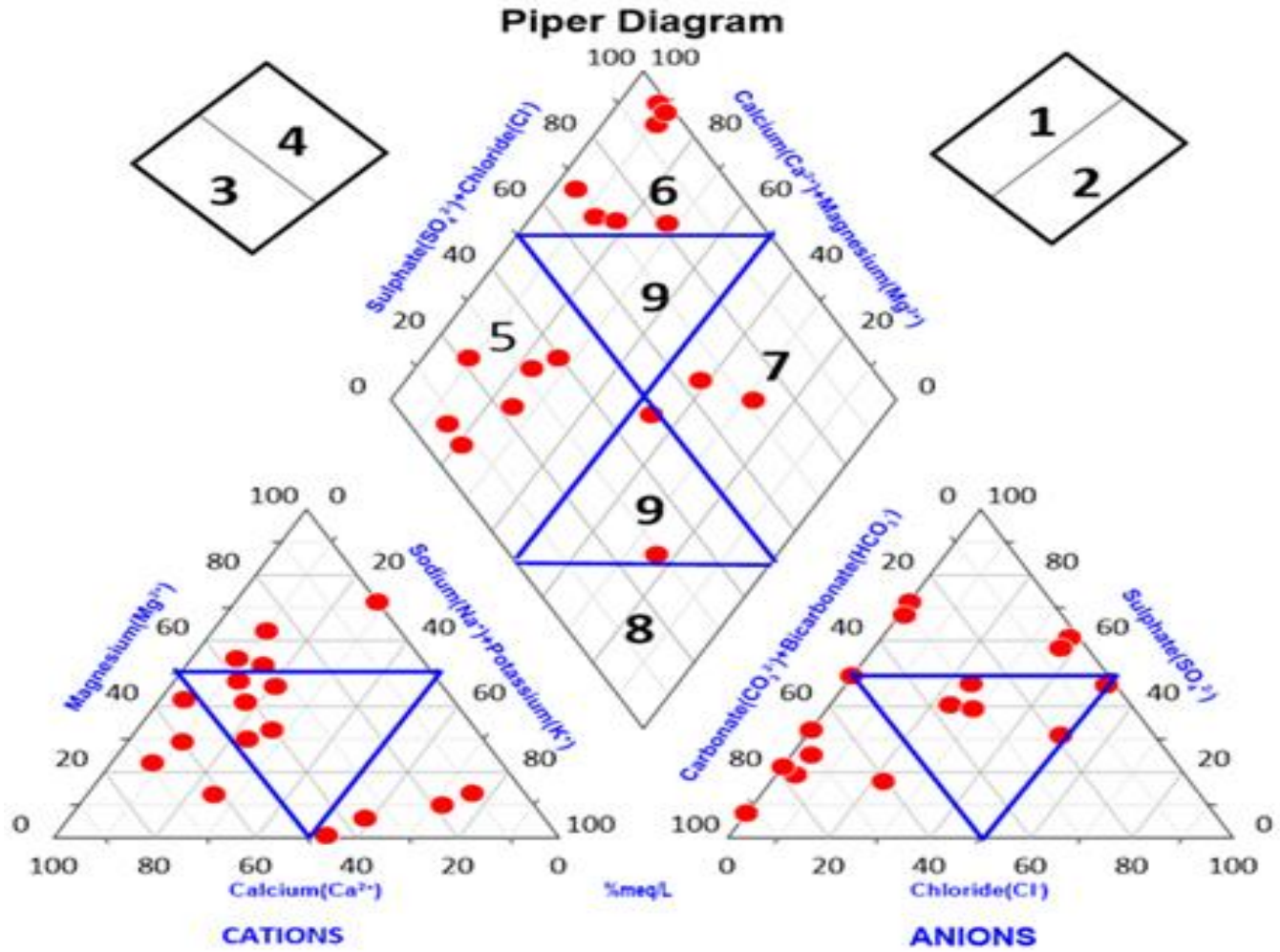
Summary of chemical concentrations of cations

	units	SAWQG standard		WHO standards		Minimum	Maximum	Average	SD
		Most desirable	Maximum allowable	Most desirable	Maximum allowable				
K^+	mg/L	<50	0-50	<10	1-25	4.25	22.94	11.62	5.5
Na^+	mg/L	<100	0-200	0.1-1.0	100	0	93.66	17.14	23.3
Ca^{2+}	mg/L	<50	0-250	<75	10-75	0.16	115.80	49.79	28.71
Mg^{2+}	mg/L	<50	0-100	<50	1-50	0.25	114.29	46.05	30.46

Summary of chemical concentrations of anions

	units	SAWQG standard		WHO standards		Minimum	Maximum	Average	SD
		Most desirable	Maximum allowable	Most desirable	Maximum allowable				
NO_3^-	mg/L	<10	10-50	<25	1-25	0	79.93	7.19	20.67
Cl^-	mg/L	<100	100-250	<25	2-25	0	355.05	43.42	93.30
SO_4^-	mg/L	<100	100-300	<10	0.1-10	1.10	428.69	67.42	111.65
HCO_3^-	mg/L	-	-	-	-	3.79	30.95	10.90	7.98

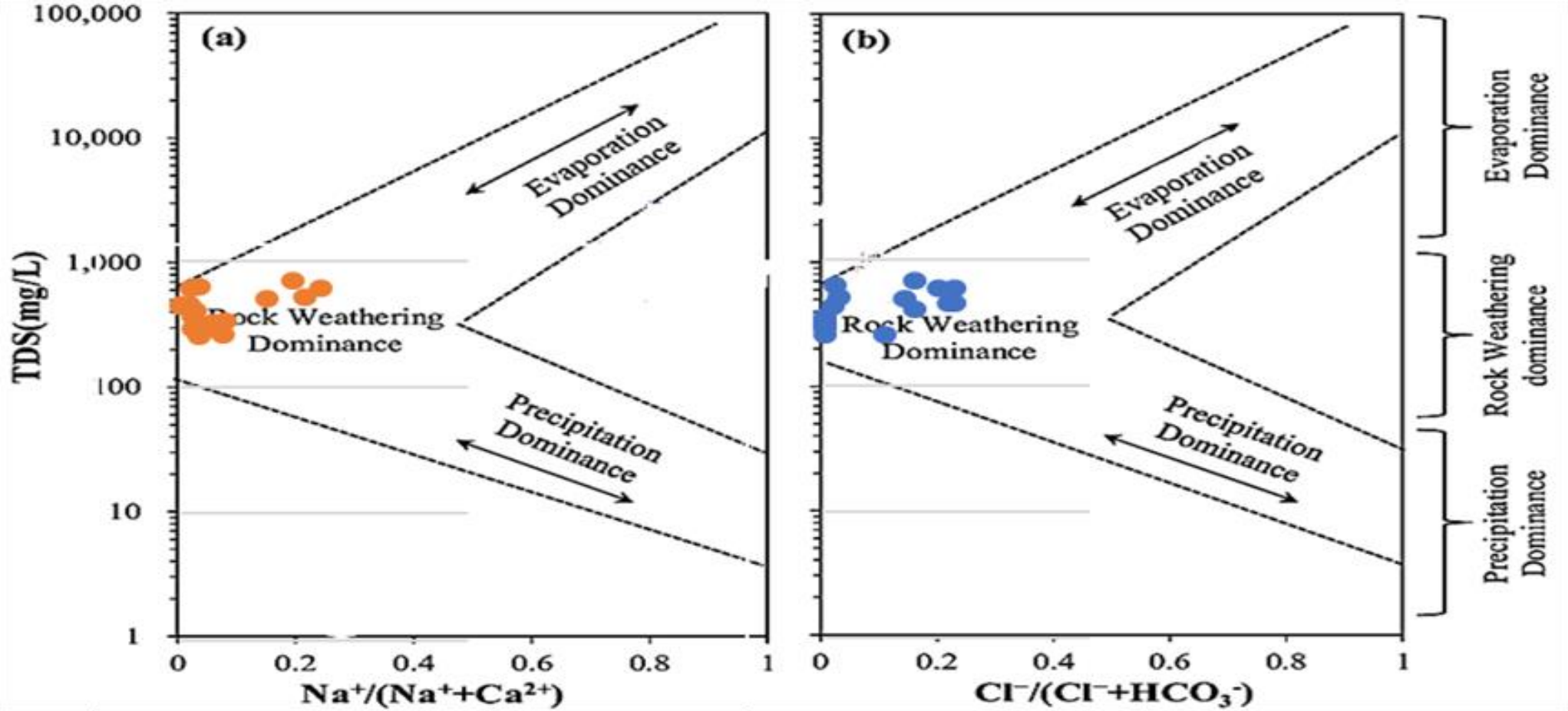
Piper diagram results



Piper results

Triangular ternaries portions	Representation of hydro-geochemical facies	Number of boreholes
1	Alkaline ($Ca^{2+}+Mg^{2+}$) exceed alkalis ($Na^{+}+K^{+}$)	13
2	Alkalis ($Na^{+}+K^{+}$) exceed alkaline ($Ca^{2+}+Mg^{2+}$)	4
3	Weak acid ($CO_3^{-}+HCO_3^{-}$) exceed strong acids ($SO_4^{2-}+Cl^{-}$)	8
4	Strong acids ($SO_4^{2-}+Cl^{-}$) exceed weak acids ($CO_3^{-}+HCO_3^{-}$)	9
5	Magnesium bicarbonate type	6
6	Calcium chloride type	7
7	Sodium chloride type	2
8	Sodium bicarbonate type	1
9	Mixed type (cations-anions do not exceed 50%)	1

Gibbs diagram results



CONCLUSION

- In this study, the results revealed that most of the groundwater samples are within the desirable limits of drinking water guidelines set by both the SAWQG and WHO. Generally, water within the study area is fit for human consumption.

- The groundwater hydrogeochemistry within the study area is dominated by the Ca-Cl type facies, which typically represents fresh water and followed by Mg-HCO_3. The study revealed that there is only one type of Na-HCO and the mixed type of Ca-Na-HCO

- In general, the geologic controls within the study area is governed silicate weathering, ionic exchange and chloride dissolution

RECOMMENDATIONS

- Extensive groundwater quality parameters need to be studied, which include presence of heavy metals within the aquifer. Grootfontein is located within the North West Dolomite and based on the flow recharge, the aquifer is likely to be polluted by heavy metals from the East Rand mines near Johannesburg

- Since water resources are interconnected by various systems including rivers, lakes, wetlands and aquifers, there need to put in place proper mitigation measures to preserve the quality of water within the Grootfontein aquifer. Therefore, studies to understand the aquifer systems using quantitative and qualitative assessment need to be done. Thus, services provided by groundwater such as baseflow to rivers and wetlands need to be recognised and protected within the planning framework.

THANK YOU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