Soil chemical and physical status in relation to distance from the fence-line in six semi-arid communal grazing lands and impact of exclosure

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Background

- Vast African rangelands are communally used for livestock production and extraction of other rangeland products
- Large proportion of these rangelands show an evidence of degradation and decreasing trends in soil elements concentrations
- The causes of degradation in communally used rangelands are subjected to debate
- The change in spatial patterns of soil physical and chemical properties has been reported in response to some environmental factors
  - such as soil type
  - biotic factors (growing livestock populations & subsequent overstocking as well as in)
  - response to poor land-use management

Problem Statement

- In South African communal rangelands, the local and spatial distribution of soil properties has not been adequately documented,
- in particular, in response to disturbance, distance and abiotic factors
- there is a lack of information on soil chemical and physical properties
- But in the country, empirical evidence that investigated the effect of enclosures on soil variables is lacking.
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Justification

- The use of enclosures has globally gained popularity as an e ective strategy to enhance soil nutrient contents and properties,

- Contributes to debates of the factors responsible for changes in soil physical and chemical properties in the semi-arid communal grazing systems

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Objectives

Soil texture and element concentrations were determined in six communal lands located in three soil types to investigate:

(1) their patterns across the grazing lands from the fence line to further away

(2) between communal lands with different grazing history, and

(3) between enclosed and open grazing lands in each communal land of the three soil types

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Table 1 Soil types, altitude & mean ± SE estimated based on three-year (2011–2013) stocking rate

			Stocking rate	(heads ha-1)
Communal grazing land	Soil type	Altitude (m a.s.l)	Cattle	Goats
Calderwood	Shallow, red stony-ground	526	3.5 ± 1.8	3.7 ± 1.1
Phumlani	Shallow, red stony-ground	557	3.1 ± 1.1	3.9 ± 1.8
Cwarhu	Shallow, dark sandy-loam	521	2.7 ± 1.1	2.9 ± 1.0
Ngwenya	Shallow, dark sandy-loam	573	2.1 ± 0.9	3 ± 1.1
Sakhi	Shallow, dark sandy-loam	475	2.4 ± 3.5	3.1 ± 4.1
Madubela	Deep, dark clay-loam	544	1.5 ± 0.2	1.9 ± 0.09

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Materials and methods

- Av. rainfall is 480 – 500 mm p.a, in all the soil types
- max and min temp. 26 - 41^{0}C in summer and 5 - 11^{0}C in winter
- Livestock types:

  - Cattle

  - Sheep

  - Goats &

  - Donkeys

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Site selection and lay out

- Six communal grazing areas, two in SRSG, three in SDSL and one in DDCL soils were selected
- In each communal area, six transects radiating out from the fencing line along the main road were established (length 1-2km)
- Each transect was divided to form sub–transects with initial points at
- near within 100 m, middle (> 100 - ≤ 300 m) and
- far sites (>- 300 m) away from the fence depending on the vegetation change

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Mineral analysis

- Two topsoil samples (to a depth of 20 cm) were taken from each 1m x 1m (protected) and (unprotected) using a soil auger
- Analysis for: Soil texture (Sand, Silt & Clay),
- (N, Ca, K, Mg, P, OC, Cu, Zn & Mn)

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Statistical analysis

- General linear models (GLM) procedure of SAS (2001)

- to test differences between protected, & unprotected plots, sites &

distance

- Data analysis was done separately for the three soil types

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Results and Discussion

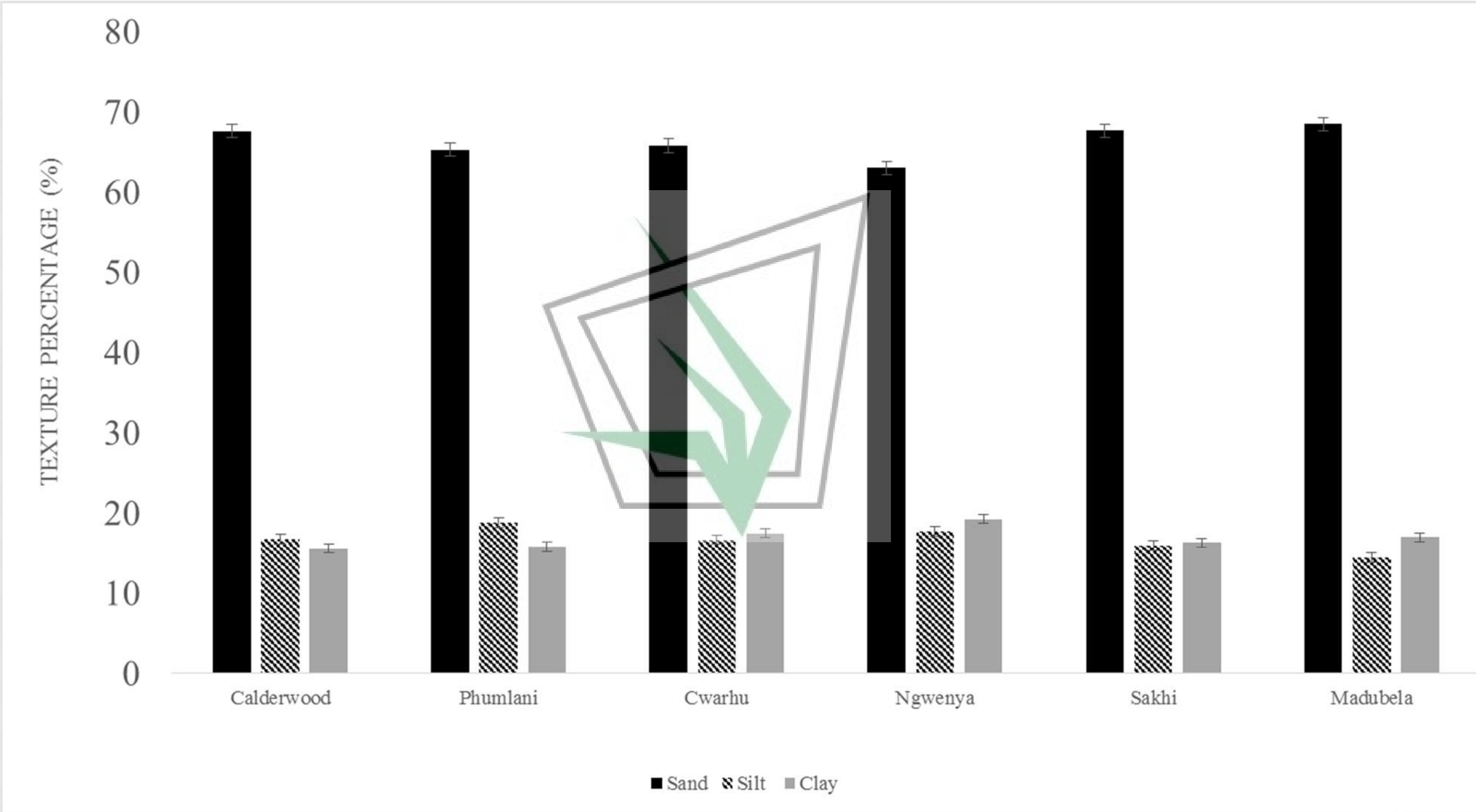

Figure 1 Texture composition (%) of top soil sampled from three soil types

minerals of soils sampled from different grazing sites in three soil types

soil elements	Soil types								
	SRSG			SDSL			DDCL		
	Prot	Unprot	SE	Prot	Unprot		Prot	Unprot	SE
Ca (cmol kg^{-1})	4.17^{a}	3.95^{a}	0.23	3.34^{a}	3.07^{a}	0.18	3.01^{a}	2.33^{b}	0.19
K (mg kg^{-1})	258.16^{a}	235.25^{a}	24.66	214.11^{a}	203.55^{a}	16.38	174^{a}	188.66^{a}	16.70
Mg (cmol kg^{-1})	1.49^{a}	1.38a	0.07	1.54^{a}	1.31^{b}	0.07	1.16^{a}	0.97^{b}	0.05
P (mg kg^{-1})	9.91^{a}	9.66^{a}	1.11	8.94^{a}	7.51^{a}	0.60	15.33^{a}	11.83^{b}	1.09
OC (%)	1.78^{a}	1.62^{a}	0.11	1.41^{a}	1.25^{b}	0.04	1.48^{a}	1.50^{a}	0.09
N (%)	0.13^{a}	0.13^{a}	0.11	0.11^{a}	0.09^{b}	0.004	0.12^{a}	0.12^{a}	0.008
Mn (mg kg^{-1})	172.96^{a}	149.30^{b}	10.64	190.14^{a}	140.43^{b}	7.59	253.55^{a}	213.63^{b}	23.97

^{a,b,} In a row, means with the same lowercase superscripts do not differ ($P > 0.05$); SEM, standard error of means.

Prot = Protected; Unprot = Unprotected.

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Macro-mineral status of soils sampled from different grazing sites in three soil types

Site	Distance points					
	Ca (cmol/kg)			K (mg/kg)		
SRSG	Near	Middle	Far	Near	Middle	Far
Calderwood	4.26^{Aa}	3.87^{Ba}	2.72^{Bb}	314^{Aa}	287^{Aa}	210^{Ab}
Phumlani	3.97^{Ab}	5.26^{Aa}	4.28^{Aab}	247^{Aa}	192^{Ba}	229^{Aa}
SEM	0.41	0.41	0.41	41.8	41.8	41.8
SDSL	Ca			K		
	Near	Middle	Far	Near	Middle	Far
Cwarhu	3.43^{Ba}	2.96^{Ab}	3.29^{Aab}	114.8^{Ba}	148^{Ba}	170.7^{Ba}
Ngwenya	4.33^{Aa}	3.37^{Ab}	2.53^{Bc}	260.8^{Aa}	234.5^{Aa}	219^{Aa}
Sakhi	3.24^{Ba}	3.29^{Aa}	2.43^{Bb}	229^{Aa}	277.5^{Aa}	225.3^{Aa}
SEM	0.39	0.39	0.39	34.8	34.8	34.8
DDCL	Ca			K		
	Near	Middle	Far	Near	Middle	Far
	1.97^{b}	2.53^{b}	3.50^{a}	192.5^{a}	189.8^{a}	163^{a}
SEM	0.24	0.24	0.24	20.5	20.5	20.5

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Macro-mineral status of soils sampled from different grazing sites in three soil types

Site	Distance points					
	Mg (cmol/kg)			P (mg/kg)		
SRSG	Near	Middle	Far	Near	Middle	Far
Calderwood	1.42^{Aa}	1.22^{Bab}	0.97^{Bb}	10.5^{Aab}	11.2^{Aa}	7.5^{Bb}
Phumlani	1.48^{Ab}	2.03^{Aa}	1.50^{Ab}	7.8^{Ab}	9.3^{Aab}	12.8^{Aa}
SEM	0.13	0.13	0.13	1.90	1.90	1.90
SDSL	Mg			P		
	Near	Middle	Far	Near	Middle	Far
Cwarhu	1.79^{Aa}	1.43^{Aa}	1.60^{Aa}	9.75^{ABa}	6.75^{Aa}	8.75^{Aa}
Ngwenya	1.52^{Aa}	1.28^{Aab}	1.01^{Bb}	12.3^{Aa}	8.50^{Ab}	4.75^{Bc}
Sakhi	1.51^{Aa}	1.46^{Aa}	1.25^{ABa}	7.25^{Ba}	8.25^{Aa}	7.75^{ABa}
SEM	0.16	0.16	0.16	1.27	1.27	1.27
DDCL	Mg			P		
	Near	Middle	Far	Near	Middle	Far
	0.96^{a}	1.08^{a}	1.15^{a}	14^{a}	14.8^{a}	12^{a}
SEM	0.06	0.06	0.06	1.34	1.34	1.34

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- [a,b,c] In a row, means with the same lowercase superscripts do not differ (P > 0.05);
- SEM, standard error of means.

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Organic carbon (%) and nitrogen (%) status of soils sampled from different grazing sites in three soil types

Site	Distance points					
	OC			N		
SRSG	Near	Middle	Far	Near	Middle	Far
Calderwood	1.45^{Ba}	1.08^{Ba}	1.26^{Ba}	0.14^{Aa}	0.12^{Bab}	0.09^{Bb}
Phumlani	2.05^{Aa}	2.41^{Aa}	1.96^{Aa}	0.12^{Ab}	0.16^{Aa}	0.14^{Aab}
SEM	1.26	1.26	1.26	0.01	0.01	0.01
SDSL	OC			N		
	Near	Middle	Far	Near	Middle	Far
Cwarhu	1.19^{Bb}	1.26^{Bb}	1.55^{Aa}	0.08^{Bb}	0.08^{Bb}	0.11^{Aa}
Ngwenya	1.49^{Aa}	1.37^{ABa}	1.02^{Cb}	0.12^{Aa}	0.11^{Aa}	0.07^{Bb}
Sakhi	1.34^{Aa}	1.44^{Aa}	1.33^{Ba}	0.10^{Aa}	0.11^{Aa}	0.10^{Aa}
SEM	0.09	0.09	0.09	0.01	0.01	0.01
DDCL	OC			N		
	Near	Middle	Far	Near	Middle	Far
Madubela	1.37^{a}	1.70^{a}	1.41^{a}	0.1^{1a}	0.13^{a}	0.12^{a}
SEM	0.12	0.12	0.12	0.01	0.01	0.01

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- ^{a,b,c} In a row, means with the same lowercase superscripts do not differ (P > 0.05);
- SEM, standard error of means.

Micro-mineral (mg kg^{-1}) status of soils sampled from different grazing sites in three soil types

Site	Distance points								
	Cu			Zn			Mn		
SRSG	Near	Middle	Far	Near	Middle	Far	Near	Middle	Far
Calderwood	1.68^{Aa}	1.77^{Aa}	0.71^{Bb}	1.14^{Aa}	0.70^{Ab}	0.57^{Ab}	221.67^{Aa}	174.42^{Aa}	93.53^{Bb}
Phumlani	1.45^{Aa}	1.42^{Aa}	1.32^{Aa}	0.66^{Ba}	0.81^{Aa}	0.75^{Aa}	160.60^{Ba}	156.06^{Aa}	160.52^{Aa}
SEM	0.21	0.21	0.21	0.11	0.11	0.11	18.43	18.43	18.43
	Cu			Zn			Mn		
SDSL	Near	Middle	Far	Near	Middle	Far	Near	Middle	Far
Cwarhu	2.05^{Ba}	1.95^{Ba}	1.36^{Cb}	0.95^{Ba}	0.80^{Aa}	0.55^{Aa}	225.30^{Ba}	59.61^{Cb}	91.69^{Bb}
Ngwenya	2.60^{ABa}	2.53^{Aa}	2.47^{Aa}	2.57^{Aa}	1.17^{Ab}	0.54^{Ab}	277.82^{Aa}	243.07^{Aa}	179.92^{Ab}
Sakhi	2.66^{Aa}	2.29^{ABa}	1.47^{Bb}	0.62^{Ba}	0.85^{Aa}	0.63^{Aa}	175.50^{Ca}	142.65^{Ba}	91.97^{Bb}
SEM	0.22	0.22	0.22	0.49	0.49	0.49	16.11	16.11	16.11
	Cu			Zn			Mn		
DDCL	Near	Middle	Far	Near	Middle	Far	Near	Middle	Far
	2.13^{a}	1.99^{a}	2.23^{a}	1.55^{a}	1.46^{a}	1.06^{a}	266.17^{a}	263^{a}	171.60^{b}
SEM	0.18	0.18	0.18	0.18	0.18	0.18	29.36	29.36	29.36

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- ^{a,b,c} In a row, means with the same lowercase superscripts do not differ (P > 0.05); SEM, standard error of means.

CONCLUSION

- The results of this study showed that enclosures are effective in restoring the nutrient status and quality of degraded soils.

- Restoration of the soil quality in communal enclosures was rated successful when compared to the open grazing area.

- There is a need for a comprehensive assessment of the long-term dynamics of soil nutrient in relation to climate for better understanding of the bene ts of enclosures for adapting to climate variability.

- Therefore, in follow-up management policies, different soil types should adopt corresponding management practices

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Which method you prefer for communal rangelands??