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Physicochemical Properties of Soil Analysis under Rangeland Traditional Management Practice on Shilavo District, Somali Regional State, East Ethiopia

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Authors' contributions

This work was carried out in collaboration among all authors. Author MH designed the study, technical writing and wrote the first draft of the manuscript. Authors ZT and MA managed the analyses of the study, performed the statistical analysis and wrote the protocol. Author DS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Traditional management practice is emerging as one of the strategies to rehabilitate and restore degraded soils. In this study the important roles of area enclosure with comparison to an open sites were investigated for physicochemical properties of soil in rangeland of Shilabo district Somali region, east Ethiopia. The management types (5 yrs enclosures, 10 yrs enclosure and open grazing land) were taken as treatments. The sand, silt and clay content of CGL, 5E and 10E were

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78, 76 and 75%; 8.67, 12.00 and 14.67% and 14.67, 10.33 and 10.33% respectively. Where the mean value of N, P and K for CGL, 5E and 10E were 0.04, 0.14 and 0.16%; 3.72, 3.91 and 5.96 mg/L and 0.16, 1.05 and 1.53 (cmol (+)/Kg soil respectively. The soil variable results revealed that soil organic matter, CECs, exchangeable Cat ions and soil moisture were significantly improved as a result of the enclosure. This study generally shows that area enclosure is a promising strategy to rehabilitate degraded environments as it is fast, cheap and lenient.

Keywords: Degraded soils; physicochemical properties; soil organic matter; soil moisture; Shilavo.

1. INTRODUCTION

Traditional management practice is emerging as one of the cheap strategies to rehabilitate and restore degraded soils in the rangeland areas. Rangelands represent about 70% of worldwide rummage for both household and wild creatures. Rangelands spread about 62% of the all out landmass of the global. Roughly 12-15 million peaceful and agro pastoral networks are supported in seven regional conditions of the world. The majority of these areas have been subjected to loss of nutrients and biodiversity changes, soil organic matter and land deterioration due to vegetation removal by livestock burning, and climate variability (Belay, 2015). The Somali Regional State is a major pastoral habitat in Ethiopia. It has a total land area is around 327,000 km^2 of which about 90% is classified as rangeland [1]. The populations in Somali region greatly depend on natural forest resources for their basic livelihood in many forms. However, the rangeland bio-physical conditions such as vegetation cover, soil fertility, feed mass production and plant bio-diversity are degrading at an alarming rate, resulting in deteriorations in the range-livestock production systems and the pastoral livelihoods in the region [1].

Because of different interactions among various biological, environmental and social factors, the rangeland management is difficult [2]. Pei et al. [3] screened that numerous studies have indicated that the overgrazing of rangeland causes a decline in quality of bio-physicochemical properties results in dramatic changes in vegetation and modifications in nutrient cycling; indeed, it could lead in the permanent degradation of land productivity and the ecosystem destruction. Raiesi and Riahi [4] stated that the effects of animal grazing on soil such quality as physicochemical and microbiological properties of soil have been reported in many rangeland ecosystems ethiopia and in most cases, rangeland over or continuous grazing resulted in severe soil erosion and subsequently land degradation. Mureithi et al. [5] it been mentioned that withdrawal of livestock grazing is often not sufficient to initiate the autogenic recovery of soil. Which so important the sustaining soil condition.

The influence of livestock grazing on plant diversity, physicochemical properties of soil decline are the major problem in many parts of Somali region rangeland and particularly communal grazing land is very common that leads very serious soil in soil condition (3). For this concept it clear that soil in somali region is in danger of becoming seriously degrading owing to natural and human-induced factors. They are under pressure by various drivers of change and there are considerable difficulties in assessing these changes and what they may mean for human use of rangeland resources. Heavy grazing pressure and climatic factor such as elevation can influence soil erosion and rangeland degradation, increase bush density. Such changes would influence the productivity [3]. Sustainable utilization and management of rangelands ecosystem in the area. In view of the increasing adoption of rangeland enclosure and the pressure exerted on the remaining communal grazing areas, it is important to understand rangeland traditional practice effectiveness in restoring declined of soil property [4]. Despite the obvious rising issues of private grazing, enclosures within the communal and consequent physicochemical of soil resulting ecological implications for rangeland resource and there have not been studies considered or investigated how the enclosure has impacts on soil parameters in the rangeland of shilavo district.

The study was to analyze physicochemical properties of soil in Rangeland of Shilavo District and to determine the changes brings on selected physical and chemical property of soils under area enclosures (traditional practice of rangeland) in comparison with the adjoining communal gazing land.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

Shilavo (Somali: *Shilaabo*) is one of the districts in Korahe zone of the Somali Regional state of Ethiopia. Part of the Korahe Zone, Shilabo is bordered on the southwest by the Gode Zone, on the west by Debeweyin, on the northwest by Kebri Dahar, on the northeast by the Werder Zone, and on the southeast by Somalia. The major settlement in Shilavo is Shilavo. The major somali group's inhabited ogaden Bahgeri and makaahil mousagomcadle clan, The woreda Shilavo is the place where found the natural gas of the Ogaden region. Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), this district has a total population of 107,590, of whom 67,376 are men and 34,214 women. While 4,924 or 8.55% are urban inhabitants, a further 36,969 or 64.19% are pastoralists. 98.8% of the population said they were Muslim.

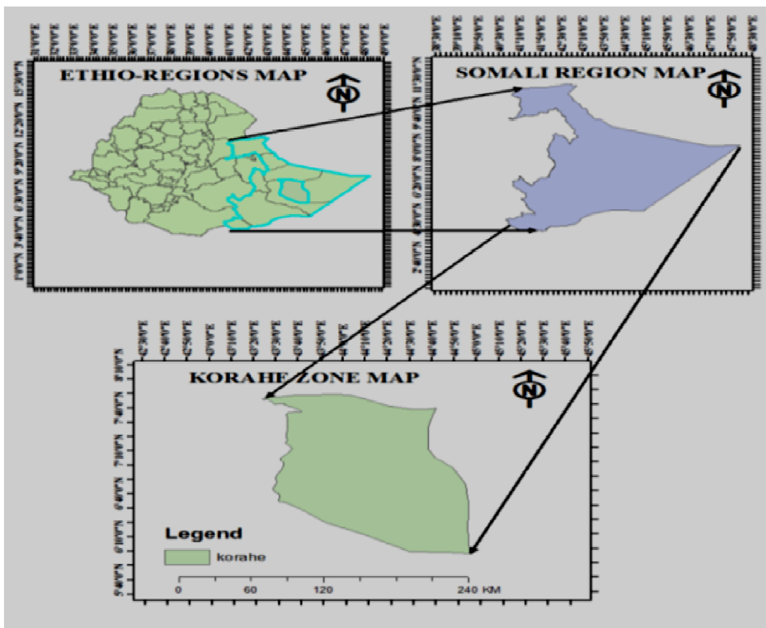

Fig. 1. Study area map

2.2 Experimental Materials and Design

Different materials were used in the experiment. These materials are Meter, spade, sack, auger, polythene bags, rope, and meter. The experiment was conducted in MAY, 2019 at Shilabo enclosures and open rangelands with an area of 484 m^2 and relative location of 6°6`N and 44°46`E. Each management type was farther laid out in to three blocks (Block one (B_1), Block two (B_2) and Block three (B_3) based on vegetation cover. The field would be designed in a randomized complete block design, for management types as random block and Sampling Site as a fixed effect.

2.3 Soil Sampling

The management types (5 yrs enclosures, 10 yrs enclosure and open grazing land) were taken as treatments. The sampling sites for both enclosures and open rangelands were selected purposely due to the accessibility located at 22 x 22 m and categorized into three blocks (6 x 20 m each) based on vegetation cover. Top plant debris was removed at 1-10 cm depth by using sharp knife. Three transects were laid at each block and five samples (4 samples at corners and 1 sample at the center) was taken and composite as 1 sample. Accordingly, from each management type, three composite samples were taken by using auger at 5 m intervals with 10-20 cm depth. Finally, 500 g of 9 composite soil samples (3 blocks x 1 composite sample x 3 management types) were prepared, labeled, sealed and transported to Haramaya University soil laboratory for analysis.

2.4 Soil Data Collection Procedure

Selected physical and chemical parameters of soil samples such as Total nitrogen, Available phosphorus, Available Potassium (AV.K), Exchangeable Calcium (Ca^{2+}), Exchangeable Magnesium (Mg^{2+}), Power of Hydrogen (pH), Organic Carbon (OC) and OM can be calculated by using conversion factor of 1.724 (OM=1.724*OC), Cat ion Exchange Capacity (CEC), Moisture Content (MC), electrical conductivity (EC) and soil texture will be obtained from Haramaya University Soil Laboratory.

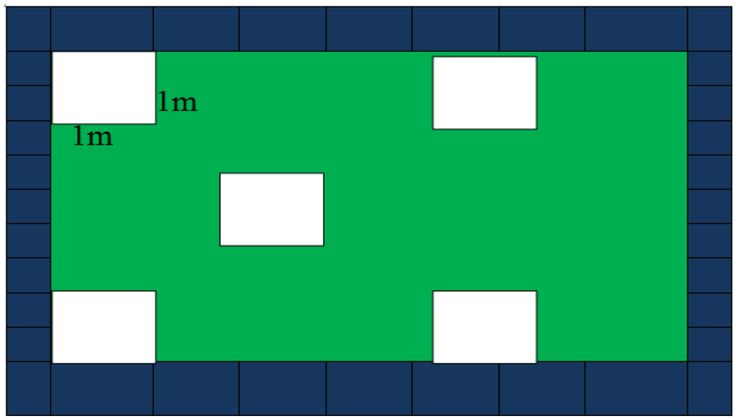

Fig. 2. Soil sampling design

Fig. 3. Taking soil sample using augur inside of enclosure

Moisture contents were determined by gravimetric method [6]. Electrical conductivity was measured on the calibrated EC meter and set temperature Compensation to 25°C, the cell is inserted dip to the extract and conductivity is recorded. Therefore, Electrical conductivity is recorded at ES ISO 11265:2014 (1:5). Power of Hydrogen was measured potentiometrically in the supernatant suspension of 1:2.5 soil distilled water/ kcl mixture using A3-point calibrated PH-meter while organic carbon was determined by using walkely and black method [7]. Cat ion exchange capacity was determined by using Ammonium acetate method [8].

Soil texture was determined by using Bouyoucos Hydrometer method [9] and Total nitrogen was determined by Kjeldahl digestion method [10]. K, Ca, Mg and Na were extracted by using Mehlich-3 extraction method [11,12]. Available phosphorus was determined by Olsen et al. [13].

2.5 Soil Data Analysis

Raw Data were subjected to one way analysis of variance (ANOVA) by using general linear model (GLM) of the SAS statistical package version 9.0 [14] followed by SAS Institute, [14] to determine the existence of any statistical difference among the treatments. Tukey multiple comparisons were used to test significant differences among the means Separations of significant differences between and among treatment means were done by using least significant difference (LSD) at 5% probability level [15].

3. RESULTS AND DISCUSSION

3.1 Physicochemical Properties of Soil

Soil texture: Texture of soil samples for the closures and open grazing land was generally classified as Sand, silt and clay respectively (Table 1). The sand fraction values were statistically significant ((P=0.028) for the three treatments. The mean percentages of sand for the treatments stand at 78, 76 and 75% for open grazing land, Enclosure1 and Enclosure 2 respectively (Table 1).

Table 1. Soil texture

Trts	Sand (%)	Silt (%)	Clay (%)
CGL	78.0 ± 1.0^{b}	14.7 ± 1.2^{a}	10.3 ± 0.6^{b}
5E	76.0 ± 76.0^{a}	8.7 ± 1.0^{b}	14.7 ± 0.6^{a}
10E	75.0 ± 3.0^{a}	12.0 ± 2.3^{ab}	14.7 ± 1.5^{a}
P	0.028	0.011	0.003

Note: Trt: Treatment, CGL: Communal grazing land, 10E: Area enclosed ten years, 5E: Area enclosed five years

The amount of sand under open grazing land was greater than the enclosures. This is probably due to the systematic removal of clay particles that leaving the sand particles in the free pasture land [16].

Under scattered vegetation covers the clay fractions of clay likely to be lost to processes of erosion and migration down the soil profile [17].The mean percentage of silt under open grazing land was greater than that of the enclosures. The ANOVA showed that statistically, there was significant difference (p = 0.011) on the silt fraction between the CGL, 5E and 10E. This is contradicted with Abinet Tadesse [16] who stated that there was no significant difference (p> 0.05) on the silt fraction between open grazing land and the area enclosures.

The mean percentage of clay was lower in open grazing land than the enclosures (Table 1). The clay content values for the three treatments were statistically significant (P= 0.003). The low organic matter, the trampling effect of livestock and the sparse vegetation aggravate soil erosion which selectively removes clay from the open grazing land. The higher clay content in the enclosures means that there is relatively low soil erosion in the site, while the lower clay in the open grazing land means there is relatively higher soil erosion at the open grazing land, which might reflect the differences in their vegetation cover. The presence of good vegetation cover in the area enclosure reduced erosion through addition of organic matter and surface litter.

Primary macronutrients: The total nitrogen in CGL was less than that of the enclosures. Results of this enquiry are in line with the findings Yimer et al. [18], who reported that the higher total nitrogen content in the enclosures is the result of higher soil organic matter content and the presence of leguminous plants which have the capacity to fix nitrogen from the atmosphere through the roots' nodules.

The mean values of Total nitrogen content for open grazing land, 5E and 10E were 0.0, 0.1 and 0.2% respectively. The total nitrogen was significantly different (<0.0001) for the three treatments (CGL, 5E and 10E) (Table 2). This finding is in agreement with work done by other researchers. According to the study by Abiy Tsetargachew [19], there was significant difference on total nitrogen between open grazing land and enclosures. The significant difference on total nitrogen in the free grazing land and the enclosure is due to difference in soil organic content and intensities of soil erosion.

The mean values of available Phosphorous values for CGL, 5E and 10E were 3.7, 3.9 and 6.0 (mg/L), respectively. The mean value of available Phosphorous for the free grazing land is higher than that of the enclosure but difference was statistically insignificant (P=0.275) (Table 2). The low available Phosphorous in the enclosure could be due to the presence of Phosphorous in its unavailable forms. From this we can conclude that the establishment of area closure did not bring a significant change on availability of Phosphorous. A similar finding (i.e. lower available phosphorous level in closed area than in free grazing land) was also reported by Abiy Tsetargachew [19] and Abinet [17]. The mean values of available potassium values for CGL, 5E and 10E were 0.2, 1.1 and 1.5 (mg/L), respectively. The mean values of available Potassium were significantly different (P<0.0001) for the three treatments (Table 2). Open grazing land had lower available Potassium (cmol(+)/Kg soil than the closed area. This is probably due to the selective removal of this vital macro-nutrient from open grazing land by accelerated erosion. Because of its high mobility in the soil, Potassium is most susceptible to leaching losses [20,17], which might be the reason for the decline of this vital micronutrient in free grazing land. Therefore, probably the higher soil leaching rates in the grazing land caused lower potassium content.

Table 2. Primary nutrients

Trt	N	P	K
CGL	0.0±0.0^a	3.7±2.2^a	0.2±0.1^a
5E	0.1±0.0^b	3.9±1.6^a	1.1±0.2^b
10E	0.2±0.0^b	6.0±1.0^a	1.5±0.0^c
P	<0.0001	0.275	<0.0001

Note: The units of N, P and K are %, mg/L and cmol (+)/Kg soil respectively

Table 3. Exchangeable cat ions

Trt	Ca^{2+}	Mg^{2+}	Na^+
CGL	10.4±0.9^a	3.2±0.3^a	0.8±0.1^a
5E	10.8±0.3^a	3.8±0.2^a	0.82±0.1^a
10E	10.3±0.6^a	3.5±0.4^a	0.9±0.1^a
P	0.683	0.146	0.824

Note: the units of Ca2+, Mg2+ and Na+ of above is (cmol (+)/Kg soil

Exchangeable cat ions: The mean values of Ca^{2+}, Mg^{2+} and Na^+ for CGL, 5E and 10E stands at 10.4,10.8 and 10.32(cmol(+)Kg^-soil);3.2, 3.8 and 3.5(cmol(+)Kg^- soil); and 0.8,0.8 and 0.9(cmol(+)Kg^- soil) respectively(Table 3).The mean values of Ca^{2+}, Mg^{2+} and Na^+ for 10E were higher than that of CGL and 5E.However, there was insignificant difference (p=0.683, 0.146 and 0.824 respectively) in Ca^{2+}, Mg^{2+} and Na^+ between the three treatments. This suggests that the three treatments did not bring any effect on these exchangeable bases. The overall mean exchangeable cat ions (cmol kg-1) of the Enclosure area and grazing area was followed the trend Ca^{2+}>Mg^{2+}>Na^+ for the three treatments. Similar findings were reported by other researchers (Abiy Thetargachew [19] and Gebremedhin Gebreanenia [21].

3.2 Some Chemical Properties of Soil

The mean values of pH stand at 8.9, 8.7 and 9.3 for CGL, 5E and 10E, respectively. The ANOVA revealed that there was significant difference (p= 0.008) in mean pH values between the soils of the Open grazing land and the enclosures at .05 significant level. This result is contradicted with the result got by Abinet Tadesse [17] who described that there was no significant difference in pH between Open grazing land and enclosure. The mean values OM, CEC and EC stands at three treatments were 0.9, 2.3 and 3.0%; 12.8, 18.8 and 21.2 meq/100 g; and 11.7, 11.2 and 11.8(us/cm) respectively. There was higher organic matter content in the soils taken from the enclosures than the open grazing land. One way analysis of variance for organic matter content for the three treatments indicated that there was significant difference (p = 0.000) in mean Organic matter (%) between the three treatments at 0.05 level (Table 4).

The reason for soil organic matter accumulation in the enclosure site could be the higher vegetation coverage of enclosure which resulted in higher litter input and thus higher accumulation of organic matter in the soil [22]. The higher clay content of the soil of the enclosures might have also contributed to higher accumulation of organic matter in the soils of the enclosures.

Soil in the enclosures showed higher in CEC than the soil in open grazing land. There was significant difference (P= 0.002) in mean values of CEC between the three treatments at 0.05 level (Table 4). This could be attributed to the higher soil organic matter and clay percentage of the soil in the enclosure site. Soil CEC is associated with clay and organic matter colloids, and especially organic matter renders soils a better CEC [23,24]. Thus, slight difference in organic matter can make a big difference in soil

Table 4. Other soil chemical properties

Trt	pH	OM	CEC	EC
CGL	8.9±0.1^a	0.9±0.1^a	12.8±2.4^a	11.7±0.8^a
5E	8.7±0.0^a	2.3±0.5^b	18.8±0.5^b	11.2±0.4^a
10E	9.3±0.2^b	3.0±0.1^b	21.2±1.4^b	11.8±2.3^a
P	0.008	0.000	0.002	0.892

Note: the units of OM, CEC and EC are %, meq/100g and µs/cm respectively

CEC as observed in this study. Similar findings were reported by other researchers Kibret Mamo [24], Abiy Tsetargachew [19]. They reported higher mean value of CEC in enclosure than free grazing lands adjacent to the enclosures. One way analysis of variance for EC for the three treatments indicated that there was significant difference (p = 0.000) in mean EC (us/cm) between the three treatments at 0.05 level (Table 4).

4. CONCLUSIONS

The findings in the current study generally show that the management types had a major impact on soil properties of rangeland. Some soil quality parameters was observed as a direct effect of heavy grazing in communal grazing land and this indicates that grazing enclosure results in altering soil physical and chemical properties which can effect plant growth in the study area. The status of the soil in the rangeland is a poor both in enclosure and communal grazing area but in the open-grazed areas was poorer than enclosure due to over grazing pressure while the status of enclosure areas was in better conditions than open grazing area. This was due to reduced disturbances. From the result of this study, we conclude that enclosures are good options for the rangeland, restoration, rehabilitation, improvement and conservation of vegetation and soil in the Shilabo rangeland as a specific and in the Somali Region as general are so important.

5. RECOMMENDATIONS

Area enclosure is an advisable and less expensive strategy of soil sustainability and rehabilitation and it need to be broad practiced with full involvements of the local community. Therefore, consideration ought to be given for the expansion of enclosures and considered as one of the best traditional management practice for the protection and restoration against soil degradation. By the way according to the result of the study, the following suggestions are forwarded.

- Open Grazing areas be modified to enclosure areas before soil organic and different nutrient contents are depleted more and the administration and conservation exercise carried out in enclosure location be bolstered in the future.
- The enclosure area should have also clear and well organized operational manual in order to control successfully, there should be alternative livestock management systems like tethering, instead of letting livestock to move freely, this will reduce overgrazing and increase land productivity in order to increase soil nutrient level in adjacent grazing lands.
- The governmental and non-governmental institutions should create awareness for the community about the importance of enclosure and give full responsibility for them to develop its sustainable management.
- For addressing the environmental problems as well as socio-economic benefits by establishing enclosures, collaboration among concerned bodies, mainly office of agriculture, local extension workers, administrative bodies and active participation of the local people, etc., is quite indispensable.

ETHICAL APPROVAL

As per University or academically standard written ethical approval has been collected and preserved by the author(s).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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