Soil Characteristics Under Different Land Use Practices in Mangochar, Kalat District, Balochistan, Pakistan

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Abstract: Land use influence soil quality of rangelands. Taking arid rangeland of Mangochar, Balochistan, Pakistan into consideration, this study investigated soil quality such as concentration of soil organic matter (SOM), soil aggregation, concentration of mineral nitrogen (N) and concentration of soluble inorganic phosphorus (P) of sites with various land use history. The sampling sites were as follows; site under unmanaged grazing, site inaccessible for grazing due to remoteness from pastoralists, field under monocropping of tomato since last 30 years and under application of organic fertilizer as cow manure, grapes field of approximately 27 years of age and under application of organic fertilizer as cow manure, apple orchards of approximately 15 and 30 years of age and under conventional farming system. Although number of native plant species and their abundance m⁻² was greater in ungrazed site as compared to grazed site, there was no significant difference in soil quality. Soils of these sites collected from sieves of 2 mm and 1 mm mesh sizes had pebbles and sand with no obvious clay or silt particles. The concentration of SOM was greater in soils of agricultural fields than ungrazed site while the higher concentration was observed for the soil from tomato field. The soils of agricultural fields also showed aggregates (rather than pebbles and sand particles) of > 2 mm, 1-2 mm and <1 - > 0.5 mm sizes. The soil of tomato field also had significantly higher pH and soluble mineral P than soils from grazed and ungrazed sites.

Keywords: Unmanaged Grazing, Soil Quality, Aggregate, Rangeland, Mangochar

1. Introduction

Rangelands are the dominant land cover of the earth that are arid and semi-arid land masses, which are more than 41% of the total land area globally [1, 2]. Rangelands provide number of ecosystem services such as livestock grazing, medicinal plants, wood for fuel purpose, prevention of soil erosion, soil carbon sequestration and hydraulic lift of underground water table via deep-rooted perennial plants [3, 4]. An estimated 35% of the human population depends on rangelands for their livelihood while around 90% of this fraction belongs to developing countries [5]. Rangelands account for ~50% of the world’s livestock production [6]. Unmanaged livestock grazing causes negative influence on vegetation cover, plant species composition and soil properties such as organic matter, aggregation and nutrient contents [7, 8]. Rangelands are also getting fragmented with their conversion into agricultural lands. With growing populations, conversion of rangelands into agricultural lands is gathering momentum [9]. The age of land use, cropping system and management practices such as use of fertilizer and tillage all influence soil quality. Whether conversion of rangelands into agricultural lands increase soil quality or further deteriorate it, is an important concern for climate and
food security-related issues [10].

Balochistan is the largest province of Pakistan that covers around 44% of the total land area of the country and rangelands comprise more than 90% of the land mass of this province [11, 12]. Most of these rangelands are subjected to unmanaged grazing to meet the requirement of local population for livestock production [11-13] while conversion of these rangelands into agricultural lands is increasing. Climate change-associated drought and high grazing pressures can have dramatically negative influence on vegetation biomass and in return soil quality [14-16], while conversion of these degraded rangelands into agricultural lands and good management practices of these agricultural lands can attenuate soil quality deterioration while also providing forage to livestock.

The rangeland of Mangochar, Balochistan receives less than 200 mm rainfall per year [14] and local people of this region utilize rangeland for livestock grazing, collection of fuel wood and medicinal plants and agriculture [14 and personal observation]. Some of the area is remote from population and thus is naturally protected from unmanaged grazing and human disturbance. The influence of human disturbance for livestock rearing or conversion of rangeland into agricultural land on soil quality is not been evaluated for this region. The aim of this study is to assess concentration of organic matter, soil aggregation, concentration of mineral nitrogen and soluble mineral phosphorus of the soil from 1) rangeland under unmanaged livestock grazing, 2) rangeland remote from human access for livestock rearing (termed as ungrazed in text), 3) agricultural fields of various ages, cropping systems and management history.

2. Materials and Methods

2.1. Study Area

This study was conducted in the rangeland of Mangochar, Balochistan, Pakistan. This rangeland has cold Mediterranean type climate and receives less than 200 mm rainfall per year [14].

2.2. Experimental Design

Soil samples were collected from six sites; site subjected to unmanaged grazing, site protected from human disturbance due to remoteness from pastoralists, tomato field, grapes orchard, apple orchard with almost 15 years of age and apple orchard of 30 years (or more) of age. Coordinates of each site and history of agricultural lands regarding use of fertilizer, cropping system and tillage practices are presented in Figure 1 and Table 1.

| Land use type | History | Fertilizer | Tillage | Farming history | EC (µs cm⁻¹) | pH |
|---------------|---------|------------|---------|-----------------|--------------|----|
| Open-for-grazing site (ungrazed site) | Age (yrs) | Cow manure | Deep plowing up to 30 cm depth | Monocropping since start | 56.95±7.85 b | 8.01±0.37 abc |
| Tomato field | >30 | Cow manure | Hand-held spade (shallow tillage up to 15 cm depth) | Since start | 64.4±54.37 b | 8.11±0.61 ab |
| Grapes field | 27 | Cow manure | Hand-held spade (shallow tillage up to 15 cm depth) | Since start | 27.14±4.48 a | 8.32±0.04 a |
| Apple orchard | ~15 | Synthetic (urea) + cow manure | Hand-held spade (shallow tillage up to 15 cm depth) | Since start | 134.62±66.42 a | 7.96±0.05 a |
| Apple orchard | ~30 | Synthetic (urea) + cow manure | Hand-held spade (shallow tillage up to 15 cm depth) | Since start | 25.74±2.57 b | 7.7±0.23 abc |

Values within column followed by different letters are significantly different (P<0.05).
In rangeland sites, 10 soil samples were collected along transect line at 10 m interval whereas five soil samples were collected from each agricultural land with random walk.

2.3. Assessment of Vegetation in Uncultivated Sites

Total of 10 plots of sizes 5 x 5 m were made along transect line in ungrazed and grazed areas. Species within plots were collected for identification.

2.4. Soil Sampling, Processing and Chemical Analysis

Soil samples from 0-5 were collected from each plot of each site by using 10 cm diameter and 5 cm height soil corer as described in Ahmad et al. [15]. Sampling was done in May. Soil samples were collected in labelled zip-lock bags, air-dried and sieved through 2 mm mesh sieve [8]. Soil organic matter was assessed by loss-on-ignition method [8]. Soil aggregation was assessed by wet sieving method as described in Qasim et al. [8]. The mineral N as nitrate (NO$_3^-$-N) and ammonium (NH$_4^+$-N) was measured following the protocol of Sims et al. [16]. Total mineral N was calculated as the cumulative of NO$_3^-$-N and NH$_4^+$-N. Soluble mineral P was assessed as described in D’Angelo et al. [17]. The samples were analyzed on UV-visible spectrophotometer (Shimadzu UV-700).

2.5. Statistical Analysis

The data was subjected to normal distribution assessment. Data were subjected to ANOVA analysis followed by least significance difference test to evaluate differences in average values of a given parameter. All the analysis was done on Microsoft excel and CoStat software.

3. Results and Discussion

There was a difference in number of plants m$^{-2}$ and number of species m$^{-2}$ between grazed and ungrazed areas. Number of plants and number of plant species were higher in ungrazed area as is evident from Table 2 and Figure 2. Grazing reduced number of species in this arid rangeland. The negative influence of unmanaged grazing on number of plant species and number of plants of a given species is reported for other arid rangelands also [18].

Table 2. Plant species found in grazed and ungrazed sites.

| Grazed site          | Ungrazed site          |
|----------------------|------------------------|
| Alhagi maurorum      | Hartia intermedia      |
| Peganum hermala      | Peganum hermala        |
| Achillea willimensii |                        |

Despite a difference in number of species, there was no difference in other soil properties parameters such as EC, pH, concentration of SOM, total mineral N and soluble mineral P between grazed and ungrazed sites as is indicated in Table 1, Figures 3, 4 and 5. Furthermore, as is evident from Figure 4, there was no difference in soil aggregate/pebbles in the large-sized sieves between grazed and ungrazed areas. Larger sieves had small pebbles and sand particles with no-to-little fine mineral particles of the soils of these sites. The possible reason of no difference between ungrazed and grazed sites is that, grazing animals secrete and defecate during rearing, which might had resulted in no difference in soil quality parameters [19].

Figure 3. Soil organic matter and aggregates/pebbles of soils of study sites. Bars with different letters indicate significant differences at P<0.05.
The soil quality of agricultural fields did not show difference than grazed and ungrazed sites except tomato field, which showed a significantly higher pH, higher concentration of SOM and total soluble inorganic P. The fields of tomato and grapes received organic fertilizer as cow manure, this might explain bigger aggregates with no pebble collected from 2 mm size mesh sieve as was observed for soil samples collected from grazed and ungrazed sites as is mentioned in Figure 3. The soil collected from all agricultural lands showed aggregates of >2 mm, 1-2 mm and > 0.5 mm sizes while the soils of grazed and ungrazed sites collected from these sieves had pebbles and sand particles. This indicates that agriculture promoted soil aggregation. This might be attributed to a significantly higher SOM in agricultural soils than the soil from ungrazed site. Our results further indicate that organic fertilizer tended to enhance soil quality than inorganic fertilizer as tomato field showed high concentration of SOM, mineral phosphorus and bigger aggregates of sizes > 2 mm, 1-2 mm and > 0.5 mm than the soil collected from apple orchards.

4. Conclusions

Our study demonstrates that unmanaged grazing reduced the number of plant species and their abundance m⁻² of this rangeland. Conversion of degraded soil of this rangeland to agricultural land tended to enhance organic matter of soil while amendment of organic fertilizer tended to enhance soil quality better than inorganic fertilizer. It merits further investigation to evaluate influence of various agricultural practices of this rangeland on other soil quality parameters such as aggregate-associated organic matter, nutrient and water holding capacity and soil fauna. Such a study will provide an insight into potential of agricultural practices in influencing soil carbon stock and soil carbon sequestration of this rangeland. Furthermore, conversion of degraded lands of this rangeland into pasture fields under organic farming can be an option to increase soil quality and reduce soil erosion besides providing food to livestock.

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