Research Article

Status of Carbon Pool in Grazed and Un-Grazed Range Lands, Pabbi Hills, Pakistan

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Abstract | Carbon sequestration study was conducted in grazed and in un-grazed sites at Pabbi hills Kharian, District Gujarat, Pakistan. The study area was surveyed and homogeneous sites for conducting experiment were selected for grazed and un- grazed range land at Pabbi hills Kharian, District Gujarat, Pakistan. Carbon is played a vital role in the green house gases. Carbon sequestration during the photosynthesis process via plant biomass is the extent of this atmospheric gas. An experiment the data for above and below phytomass for grazed and un- grazed range land was collected and carbon pool was estimated by Wet Combustion and Dry Combustion method.Four transect lines were drawn in each experimental plot. Twenty four samples of each experimental plot were collected with the help of ADC one m ^{2} quadrate methods, weighed and then oven dried at 60 ^{o}C to find out the dry weight for above pytomass carbon Mg C ha^{-1} (Brown and Lugo, 1982). Similarly, the same 1 m^{2} quadrate area was dug up to the depth of root zone for each grass and the root portion was separated, weighed, oven dried at 60 C^{o} for estimating below ground pytomass carbon Mg C ha^{-1}. Carbon pool in above ground phtyomass was 0.08 MgCha^{-1} while below ground phytomass carbon was estimated as 0.05 MgCha^{-}. In grazed and un-grazed sites, the SOC (%) MgCha^{-1} decreased depth wise as well as in total carbon MgCha^{-1}. In grazed site, the carbon decreased due to their shallow roots habit and also least portion of phytomass was left behind on the soil surface. Therefore, maximum carbon was leached down into soil. Similarly in un-grazed site, as their above portion of grass was not so grazed, but the carbon was leached into soil due to their shallow roots all the carbon leached down into soil. The carbon sequestration in underground and the aerial phytomass depends upon the management practices, climate and response of different species.

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Introduction

Pakistan total land area is 88 million ha, including Azad Kashmir and is located between 24 and 37^{o} N latitude and 61 and 75^{o} E longitude. The climate variation of Pakistan is arid with low rainfall and humidity and high solar radiation over most parts of the country. Most plain areas receive less than 250 mm annual rainfall, except for the high altitude northern mountains, which receive more than 1000 mm annually (Muhammad, 1989). Agriculture, livestock production, and forestry are the major land use pattern in the country. There are more than 150 millions livestock heads in the country. The economy of the country mostly depends on agriculture, which contributes nearly 20% to national GDP, whereas livestock share in agriculture value added is almost 56% while forestry sector share is around 2% (GoP, 2014-15). Rangelands provide nearly 60% of feed requirement for sheep and goats and about 5% for cattle and buffaloes. In addition to grazing, rangelands in northern mountain zone act as watersheds and are a major source of clean stream flow, natural habitat of wildlife and production of timber and fuel wood. Hence, rangelands provide great potential for livestock grazing and dry afforestation (Muhammad, 1989). Rangelands include; natural grasslands, savannas, deserts, tundra, alpine plants communities, costal marshes, wet meadows, and introduced plants communities managed like rangelands. There are more than 52.2 million hectares land is classified as rangelands. Out of this 18.5 million ha is considered to be productive and can be used for livestock grazing (Muhammad, 1989). Rangelands ecosystems have the high carbon (C) storage beneath the soil and are great potential of carbon sink (Bronson et al., 2004; White et al., 2000). Rangeland based adaptation strategies such as seasonal grassland reserves (Angassa and Oba 2007), revival of traditional grazing systems and development of forage reserves including grasses and fast growing plants along the road sides have the potential to play great roles in both adapting to and mitigating further climate changes (Batima, 2006). Rangeland and afforestation practices increase the organic matter inputs to soils and also decrease losses from soil respiration and erosion. Human activities such as fuel consumption and deforestation effect CO_2 concentration of the atmospheric (IPCC, 2001, Grace, 2004). Current study was carried out to assess the carbon potential in two grasslands (grazed, un-grazed) at Pabbi Hills in Pothowar region, Pakistan.

Materials and Methods

The study was conducted at Pabbi hills Kharian District Gujarat. *Cenchrus ciliarisis* being the major rangeland grass species in Pabbi hills state forest was selected for estimation of soil organic carbon (SOC) in grazed (z) and un-grazed (un-z) in the study areas. For obtaining the data of soil organic carbon (SOC) soil samplings were performed at Pabbi hills. Four parallel transects twenty five meters long each was established at each site five meters apart. Six 1 m^2 quadrats were established on the alternate site of the transect line. Soil samples were collected with a 5 cm diameter soil core in 20 cm incremental depths (0-20, 20-40, 40-60, 60-80 cm) at each site. From one transect three soil samples from one depth were collected and total number of soil samples per transect were 12 and total samples from five transects were seventy two. The three soil samples of each transect were pooled to from one sample for each soil layer at each sites. All collected samples were immediately sealed in bags. The soil samples were air dried at room temperature for three days in the LRRI, laboratory, NARC. Samples analyzed for soil organic carbon (SOC), total Carbon and inorganic carbon (SIC). The soil organic carbon (SOC) was calculated by wet oxidation method (Walkley and Black, 1947). Soil inorganic Carbon was determined by the Colorimetric method (Black, 1965). Total Carbon was calculated by Wet Combustion and Dry Combustion method (Black, 1965).

Phytomass Carbon Pool (PCP)

Vegetation rooted inside the quadrat was harvested at ground level for above ground biomass samplings. Fresh biomass production data recorded immediately after harvesting and the same samples were oven dried at 60 °C till constant weight. Below ground root biomass production were collected by digging the below ground biomass at appropriate root depth within the 1 m^2 quadrats. Roots sieved to separate roots from soil and stone. Fresh and dry below ground biomass production data recorded. Coefficient of 0.50 was used for the conversion of biomass to carbon in both above and below ground phytomass (Brown and Lugo, 1982).

Soil Organic Carbon Pool (SOCP)

The soil organic carbon (SOC) was calculated by wet oxidation method (Walkley and Black, 1947). Organic carbon was oxidized by potassium dichromate in the presence of sulfuric acid and formed the CO_2 while soil organic carbon (SOC) was oxidized and potassium dichromate is reduced. The amount of oxygen consumed during the oxidation of soil organic carbon (SOC) was calculated from the difference between the amount of potassium dichromate taken and the amount remaining after oxidation was determined by titration method with 0.5 N ferrous sulfate or ferrous ammonium sulfate in the presence of indicator diphenylamine (Black, 1965). Soil organic carbon Pool (SOCP) was calculated by the equation as suggested by IPCC Good Practice Guidance for LULUCF (IPCC, 2003).

Statistical analysis

The Experiment was laid out in Randomized Complete Block Design (RCBD). Data recorded with standard procedures were analyzed statistically using two-factor factorial. Difference among the mean were compared using LSD test at 5% probability level. Sampling sites and depths used as main factors.

Results and Discussion

Phytomass Carbon Pool (PCP) Pabbi hills

The above and below ground phytomass in grazed and un-grazed site is significantly different at ($p<0.05$). The above and below ground phytomass in grazed site was recorded as 0.16 Mg C ha^{-1} and 0.10 Mg C ha^{-1}, respectively. Similarly, the above and below ground phytomass in un-grazed site was 0.48 and 0.36 Mg ha^{-1} C pool and is significantly different at ($p< 0.05$) than the grazed site. The total carbon pool in above and below ground vegetation in grazed site is 0.13 Mg C ha^{-1} whereas in un-grazed site is 0.42 Mg C ha^{-1}. The organic matter was 25.3% in the upper soil of grazed plots. But in the un-grazed site, it was 36%, which caused the organic carbon in the upper soil (Bremer et al., 1998). Soil inorganic carbon data recorded from soil sample collected from grazed and in un-grazed sites at various depths ranged from 0.55 to 1.58. Slightly, higher SIC was recorded at depth of 60-80 cm in both un-grazed and grazed sites. The SOC was decreases at deeper soil depths in grazed as well as in un-grazed sites. In grazed and un-grazed sites the SOC (%) $MgCha^{-1}$ decreased depth wise as well as in total carbon $MgCha^{-1}$. In grazed site the carbon decreased due to their shallow roots habit and also least portion of phytomass was left behind on the above soil. Therefore, maximum carbon was leached down into soil. Similarly in un-grazed site, as their above portion of grass was not so grazed, but the carbon was leached into soil due to their shallow roots all the carbon leached down into soil. The carbon sequestration in underground and the aerial phytomass depends upon the management practices, climate and response of different species (Schuman et al., 2002). The estimation of phytomass carbon pool that assuming one ton of organic matter is equivalent to 0.5 ton of organic carbon indicate that un-grazed site has higher carbon pool in both above and below ground vegetation than the grazed site (Brown and Lugo, 1984). *Cenchrus cilinaris* in Pabbi hills areas seems a suitable grass species for both grazing and re-seeding of degraded rangelands and to increase the rate of carbon sequestration. The conversion factor of phytomass into carbon sequestration may vary among species and their growth form. The amount of carbon sequestration in the above ground phytomass was more than underground phytomass and was statistically significant. Average stored carbon in the soil in the enclosure region is more than grazed regions and this difference was statistically significant ($p <0.05$). A study was conducted by the scientist of china revealed that the continuous grazing on sandy grassland was harmful for vegetation and increased bare soil and decreased carbon storage in soil and plant systems (Su-Young and Zhao, 2003). Similarly, the re-establishment of vegetation and grazing management practices increased total carbon sequestration in biomass, litter and soil significantly. The rangelands have a large potential to sequester Carbon from the rangelands on about half of the world's land area and store greater than 10% of terrestrial biomass Carbon and 10 to 30% of global soil organic carbon from these rangelands. It is estimated that rangelands globally sequester Carbon in soil at a rate of 0.5 Pg C yr^{-1} and that soil Carbon sequestration rates are low on rangelands (Derner and Schuman, 2007). However, it has been recognized that general management practices that reduce soil erosion, prevent land degradation, or restore degraded land have the biggest impacts on soil carbon (Lal, 2002).

Hence, carbon sequestration in rangeland depends upon the environmental conditions and also more importantly the timely precipitation than the total annual amount of rainfall and the vegetation type (Svejcar et al., 2008, Knapp et al., 2002, Jobbágy and Jackson, 2000). Rangelands have generally a low per acre potential to sequester carbon but the vast rangeland area in Potohar region has great potential for sequestering carbon.

Table 1: *Above and below ground carbon pool in grazed and un-grazed sites at Pabbi hills.*

Sites	Phytomass (Mg ha-1)		Means	Carbon pool (Mg ha-1)		Means
	Above ground	Below ground		Above ground	Below ground	
G	0.16	0.10	0.13 b	0.08	0.05	0.065b
Un-z	0.48	0.36	0.42a	0.24	0.18	0.21a
Means	0.32a	0.23b		0.16a	0.11 b	

LSD (0.05) for Phytomass (Above and below ground) = 0.13; LSD (0.05) for Phytomass (G and Un-z) = 0.04; LSD (0.05) for Carbon pool (Above and below ground) = 0.07; LSD (0.05) for Carbon pool (G and

Un-z) = 0.02; G= Grazed un-z= un-grazed

Soil Carbon Pool (SCP) Pabbi hills

Significant differences were recorded at ($p<0.05$) for soil inorganic carbon (SIC) and for soil organic carbon (SOC) in grazed and un-grazed soils. SIC in grazed ranged from 0.55 to 0.61%, where as in un-grazed soil ranged from 1.33 to 1.46 (Table 2). Similarly the SOC in un-grazed soil at all depths was also higher than the grazed soil (Schuman et al., 1999). SOC in grazed soil ranged from 0.18 to 0.21% while in un-grazed soil it ranged from 0.33 to 0.87% (Table 2). SOC pool Mg ha^{-1} at all depths was higher than the grazed soil. Grazing greatly reduces the standing biomass and litter and ultimately affects the SOC (Schuman et al., 1999). The SOC content may varies from site to site due to environmental factors (Powers and Schlesinger, 2002), climate variables (Davidson and Janssens, 2006), topography (Razaei and Gilkes, 2005), soil texture (Heviaa et al., 2003), vegetation (Wang et al., 2009) and management practices (Sainju et al., 2008). Precipitation, temperature, elevation, clay, silt contents and land use practices may have significant impacts on SOCP Mgha^{-1} (Liu et al., 2011). In similar environmental conditions different stand structures and species composition have different growth and mortality rates and these differences eventually lead to differences in stand C stocks (Vayreda et al, 2012). According these estimates indicate that world's grasslands store 200–420 000 M t C, a large part of which is below the soil surface (Robert, 2001). The top soil layers (0-20 cm) and (20-40 cm) contained highest SOCMg C ha^{-1}. Around 70-75% of the root biomass in grasslands is located in the top 15 cm of the soil (Gleixner et al., 2005) and organic carbon concentrations increases in the main rooting zone but decreases beneath this zone. Eighty-four percent of that carbon resides in soil as organic carbon (Woomer et al., 2004). Similar figures are presented by (Tiessen et al., 1999) that 20–30% difference in carbon storage in the upper 20-cm layer in an area of Senegal with 500–650 mm annual average rainfall. The SOC Mg ha^{-1} decreases as the depth of soil increases. The SOC% Mg C ha^{-1} in grazed soil at various depths ranged from 2.98 to 5.68, whereas in un-grazed soils it ranges from 9.83 to 24.70. The total SOC pool at various depths in grazed soil is 17.45 Mg C ha^{-1}, while in un-grazed soil is 59.43 Mg C ha^{-1}. The soil organic carbon pool (SOCP) Mgha^{-1} was higher in un-grazed site as compared to grazed site. Standing biomass in the un-grazed site was higher than the grazed area and both standing biomass and litter have contributed higher SOCP Mgha^{-1}. The potential for sequestering carbon in soils (per unit area) decreases as annual precipitation decreases and as mean temperatures increase (Batjes, 2001). The organic carbon content may be increased only by appropriate reforestation, protection and reseeding on rangeland to sequestrate more carbon (Lal, 2004).

Soil physico-chemical properties Pabbi hills

Analysis of soil physical and chemical properties of Pabbi Hills are presented in Table 3. Significant differences ($p>0.05$) for Clay between grazed and un-grazed sites while all other soil parameters was non-significant ($p<0.05$) for main factors and interaction (Table 1). Clay of grazed site at all depths is higher than un-grazed. Clay in grazed ranged from 13 to 14.5 while in un-grazed ranged from 10.5 to 13.6% (Table 1). The texture of grazed and un-grazed soils is silt loam (Table 1). The soil organic was higher in un-grazed site than the grazed site at Pabbi Hills. This was indicated that in the un-grazed areas the carbon was more than in the grazed area. In grazed area the grazing intensity was very high resulting reduction of vegetation, reduce plant residues and soil organic matter (Su-Yong and Zhao 2003).

Table 2: *SIC%, SOC% and SOC Mg C ha^{-1} in grazed and in un-grazed soil.*

Depths (cm)	SIC (%)		Means	SOC (%)		Means	SOCP Mg C ha^{-1}		Means
	G	Un-z		G	Un-z		G	Un-z	
0-20	0.55	1.33	0.94b	0.20	0.87	0.53a	5.68	24.70	15.19a
20-40	0.59	1.46	1.02ab	0.19	0.47	0.33b	5.58	13.81	09.69b
40-60	0.61	1.45	1.03ab	0.12	0.38	0.26b	3.21	11.09	07.15b
60-80	0.61	1.58	1.01a	0.18	0.33	0.25b	2.98	9.8	06.39b
Means	0.59b	1.45a		0.19b	0.51a		4.36b	14.85a	

LSD (0.05) for SIC (G and Un-z) = 0.1094; LSD (0.05) for SIC (Soil depth) = 0.1547; LSD (0.05) for SOM (G and Un-z) = 0.1374; LSD (0.05) for SOM (Soil depth) = 0.1884; LSD (0.05) for SOCP (G and Un-z) = 6.3564; LSD (0.05) for SOCP (Soil depth) = 3.6254G= Grazed un-z= un-grazed

Table 3: *Soil physical properties of grazed and un-grazed at State Forest, Pabbi Hills, Kharian.*

Depths (cm)	Clay		Means	Silt		Means	Sand		Means	Tex Texture	
	G	Un-z		G	Un-z		G	Un-z		G	Un-z
0-20	13.00	13.62	13.31	18.12	15.0	16.56	71.12	71.37	71.24	SL	SL
20-40	14.25	11.75	13.00	15.62	15.0	10.31	70.12	73.25	71.68	SL	SL
40-60	13.62	10.50	12.06	14.37	15.87	15.12	72.00	73.62	72.81	SL	SL
60-80	13.12	12.37	12.74	16.75	23.75	20.25	70.12	63.87	66.99	SL	SL
Means	13.50a	12.06b		16.21	17.43		70.84	70.52			

LSD (0.05) for Clay (G and Un-z) = 1.4292; LSD (0.05) for Clay (Soil depths) = NS; LSD (0.05) for Silt (G and Un-z) = NS; LSD (0.05) for Silt (Soil depths) = NS; LSD (0.05) for Sand (G and Un-z) = NS; LSD (0.05) for Sand (Soil depths) = NS; G= Grazed Un-z= Un-grazed, SL=Sandy Loam

Conclusion

This study was conducted to assess the status of carbon pool for Pothowar rangelands at Pabbi hills Kharian, District Gujrat, Pakistan. Two experimental sites in grazed and un-grazed were selected. Data for above and below phytomass was collected and carbon pools were estimated. Four transect lines were drawn in each site. Twenty quadrates were laid in each site. The soil physical and chemical properties indicated that in the un-grazed areas the carbon was more than in the grazed area (Schuman et al., 1999). In grazed area the grazing intensity was very high resulting in reduction of vegetation, reduced plant residues and soil organic matter (Su-Yong and Zhao 2003). Carbon pool in above ground phtyomass was 0.32 Mg C ha$^{-1.}$ While, below ground phytomass recorded 0.23 Mg C ha^{-1}. It was concluded that the area was protected, due to which the above ground biomass was better than grazed area (Bremer et al., 1998). Similarly, the total carbon pool Mg C ha^{-1} was also more in un-grazed than grazed in above and belowground phytomass. Highest SOC was recorded at the upper (0-20 cm) depth in grazed due to having litters and standing dead (Rajan, 2011). However, the highest SIC was recorded at depth 40-60 cm, 60-80 cm in grazed and gradually increased in depth wise. In this experiment the SIC leaching process was not measured. There was one reason of higher percent of SIC at lower soil depths may be to due leaching effects and needs further detailed studies. Similarly, then, the highest SIC was recorded at un-grazed site and also decreases in depth as go down, but it may also differ from place to place. In grazed and un-grazed sites the SOC Mg C ha^{-1} decrease depth wise as well as in total carbon Mg C ha^{-1}. Grazing management practices, climate and response of different species was mandatory for biomass production and carbon sequestration in the rangelands (Schuman et al., 2002). Therefore, it has been recognized that general management practices have the biggest impacts on the soil carbon and also reduce the soil erosion, prevent land degradation (Lal, 2002).

Recommendations

Increase in carbon storage can only be done by growing more grasses for livestock and the involvement of the stakeholders by creating awareness about the carbon sequestration.

Protection of the rangelands can only be possible when there will be strong long-term political commitment by the government as well as involvement of stakeholders to prevent un-controlled grazing.

Authors Contribution

Mohammad Umar Farooq: Conceive the idea and overall management of the article.
Sarfaraz Ahmad: Technical input at every step.
Ghulam Nabi, Ijaz Ali: Support in data analysis and lab work.
Imtiaz Ahmad: Editing help during writing

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