Impact of Altitude on Soil Physical and Chemical Properties in Sra Ghurgai (Takatu mountain range) Quetta, Balochistan.

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Abstract: The objective of this study was to investigate the changes in soil physical and chemical properties across three different elevation of an area and the effect of environmental variables on the soil properties. Soil samples were collected from 3 locations located in the mountain range known as the Sra Ghurgai (Takatu range) at 1660-2133 m a.s.l. The results revealed that the soil physio-chemical properties of collected samples show significant correlation with the elevation gradient. Organic matter content of soil and Bulk Density were negatively correlated to the altitude it decreases as altitude increases with the rate of correlation coefficient -0.989 and -0.999 respectively. Soil Organic Carbon increased with increase in altitude at correlation coefficient 0.826. CaCO3 shows negative correlation decreasing with increase in altitude at the rate of correlation coefficient -0.990. Soil pH shows minor changes with the elevation gradient. EC were minimum at 1804m and maximum at 1660m with the rate of correlation coefficient -0.095. Silt had significant correlation and variation with elevation it increases with the increase in altitude with the rate of correlation coefficient 0.997 while the Sand and Clay shows negative correlation decreasing with the increase in altitude with the rate of correlation coefficient is -0.999 and -0.989 respectively. While the Micro-Macro nutrients of soil samples also show significant results toward altitude gradient. The percentage of available Phosphorus, Zinc and Copper content in the soil increased with increasing altitude with the rate of correlation coefficient 0.923, 0.995 and 0.999 respectively. While the percentage of available Iron, Manganese and Potassium show some different pattern it increased at between the elevation that is 1804m with the rate of correlation coefficient is -0.322, 0.009 and -0.181 respectively. All the physical parameters and Macro-Micro nutrients showed significant ($P < 0.001$) while some chemical parameters were significant at ($P < 0.05$. $P < 0.01$ and $P < 0.001$).The future trend of this study will play an important role in understanding the change in soil properties and its impact on plants genetic diversity and phytochemical variation with altitude gradient.

Keywords: Altitude impact; Soil Physical and Chemical Properties; Sra Ghurgai; Quetta; Balochisatn.

1 INTRODUCTION:

The term soil is usually defined as a complex mixture of eroded rock, mineral nutrients' decaying organic matter, water, air, and billions of living organisms, most of them are microscopic decomposers [1]

The altitudinal gradient of mountain is characterized by variable temperature and different precipitation records. Variable temperature and moisture differences generated from elevation and aspect gradients may have the same effect on organic matter decomposition [2]. There were considerable changes in horizon composition, including dramatic differences in soil texture, horizon depth and temperature. There were correlation between soil chemistry and elevation [3].

Altitude is often employed to study the effects of climatic variables on soil organic matter dynamics [4, 5]. Soil pH may also control biotic factors such as the activity and biomass composition. The change in altitudinal gradients influences soil organic matter by controlling soil water balance, soil erosion, geologic deposition processes, species and biomass production of the native vegetation and cultivated plants [6]. Change in other soil properties have been found to be more variable, perhaps due to differences in climate, crop rotation, soil type or length of time and soil has been under organic management [7]. Soil Bulk Density had significant correlation and variation with elevation higher average soil bulk density was observed in the soils of lower elevation as compared to those of higher elevation [8].

[20] Reported that the relationship between climate, water balance and soil chemical composition. They observed that an increase in the humidity increases the percentage of organic carbon, total nitrogen and other soil nutrients. The result indicated that the chemical compositions of soils are directly related to climatic conditions.

2 MATERIALS AND METHODS:

2.1 Site Characteristics

Sra Ghurgai located at Koh-i-Takatu, the Sulaiman Mountains range, in the Quetta District, Province, Pakistan. The altitude ranges from 1660 meters to 3000 meters above sea level. Latitude 30^{o} 17′ - 39^{o} towards North and Longitude = 67^{o} 01′- 02^{o} towards East. Mean annual

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rainfall is104.40mm. The mean annual Absolute Max air temperature is 30°C and mean annual Absolute Min air temperature is 1°C. Total area of Sar Ghurgai is 140 Sq.Km.

2.2 Sampling Protocol

Three sites were selected with different elevations. Ten composite soil samples were collected from the surface layer (0 - 30 cm depth) soils of each site. Elevation of the sampling points varied from 1660 to 2133meters above sea level.

2.3 Laboratory Analysis

The composite surface (0 - 30 cm depth) soil samples collected were air-dried and ground to pass through a 2 mm sieve. Soil texture was determined by hydrometer method [10]. Bulk density were calculated by [11]. Water holding capacity of soil was determined by following [12]. Electrical Conductivity was measured by Electrical Conductivity meter using soil saturation paste. pH of soil samples was determined by pH meter using soil saturated paste [13]. Organic Matter was determined by ignition method. [14]. Soil Organic Carbon was determined by Walkley and Black. 1934. $CaCO_3$ was determined by following [15]. DTPA Method was used to determine Zn, Fe, Cu and Mn by an Atomic Absorption. P was determined by spectrophotometer at 880-nm wavelength [16].

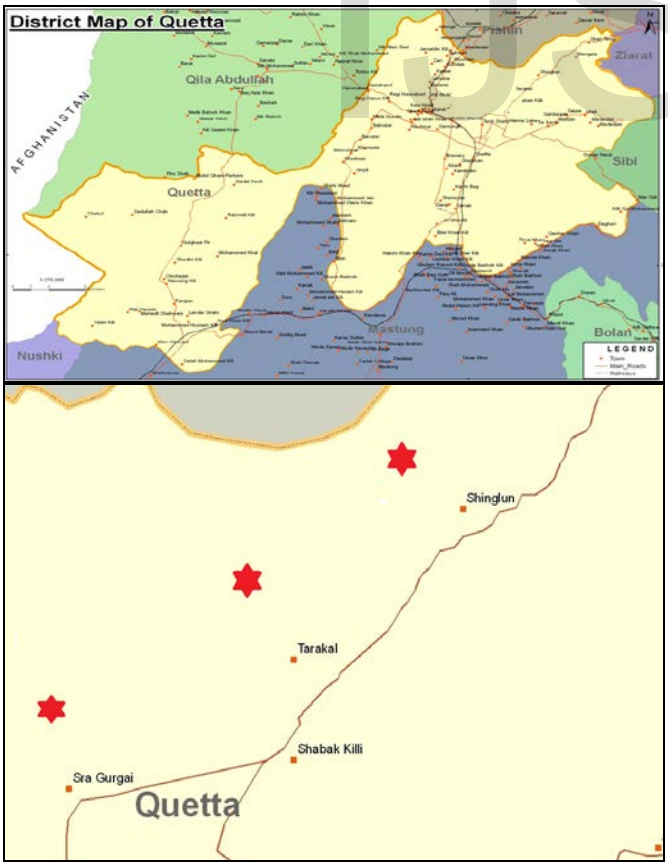

Figure 1. Map of the Quetta district and location of the study areas.

2.4 Statistical Analyses

Data were statistically analyzed. An analysis of variance was used to test differences in soil physical and chemical properties across the different elevation sites of an area. Significance level ($P<0.05$, $P<0.01$ and $P<0.001$) was generated among the different altitudinal study sites by one way ANOVA. Data analyses were done using a statistical software package [Statistix 10]. To seek the relationship between Soil bulk density, O.M, SOC, $CaCO_3$, pH, EC, Silt, Sand, Clay with the three different elevation. Correlation and regression analyses were performed. Correlations between soil variables were also performed with the software IBM SPSS Statistics 20.

3 RESULTS AND DISCUSION:

The topographic factor affects the environmental variables and the soil properties.

Table 1: Study Sites altitude description

Sampling Sites	Latitude (N)	Longitude (E)	Elevation (m)
1	30.17	67.01	1660
2	30.29	67.06	1804
3	30.33	67.08	2133

The organic matter percentage in the soil is decreasing with the increase in altitude. With the mean value 2.89±0.48 at 1660m and 1.82±0.57 at 2133m a.s.l (Table 2). That may be due to temperature because temperature decreases as altitude increases and the amount of organic material decreases because it becomes more difficult for plants to survive at higher altitudes. [3]. The organic matter content is negatively correlated to the altitude and the rate of correlation coefficient in between the altitude and the organic matter content is -0.989. And is Non-Significant with the p-value 0.222. [20, 8] also reported that the elevation gradient effects on the soil organic matter contents, it decreases with the increase in the elevation above sea level.

The Soil Organic Carbon increases as altitude increases same is the data recorded by Sevgi 2003. Increase in the SOC is due to the change in the climatic condition at higher elvation as well the decrease in OM accumulation along the elevation gradients [17, 18] results show correlation coefficient at 0.826.

Bulk density was higher at lower elevation as compare to higher elevation. It has significant correlation and variation with elevation at the rate of correlation coefficient -0.999 (Table 2). It might be due to SOM are lower in percent pore space and result in higher Bulk density. Similar results were reported by [8,9]

CaCO3 shows negative correlation it decreased with the increase in altitude with the rate of correlation coefficient is -0.990. (Fig 5) Maximum value 17.5% at 1660 m and minimum value 9.9% at 2133m elevation with the $P<0.05$

(Table 4). Earlier reported by [20]. Which was might be due to change in temperature. As the temperature influence the CaCO3 equilibrium directly.

There were minor difference in the pH with the elevation gradient our findings also supports the [19]. pH at low elevation 1660m were 7.9±0.15 while at maximum elevation 2133m it was 8.0±0.15 .(Table 3). Soil EC was minimum at 1804 m 120.7±1.0 and maximum at 1660m 210.7±16.5 with the rate of correlation coefficient -0.095.

Table2: Soil Bulk Density, OM and SOC (Means± SD) status across three different elevation sites.

Site name	Altitude (m)	Bulk Density (g cm -3)	Organic Matter (%)	Soil Organic Carbon %
1	1660	1.12±0.01	2.89±0.48	1.07±0.34
2	1804	1.09±0.01	2.71±0.16	1.60±0.09
3	2133	1.03±0.01	1.82±0.57	1.70±0.28

Table 3: Altitudinal variation in physical and chemical properties across three different elevation sites

Parameters	Site 1	Site 2	Site 3
CaCo3 (%)	17.5±2.91	16.2±1.76	9.9±4.05
pH	7.9±0.15	7.4±0.15	8.0±0.15
EC (µs/cm)	210.7±16.5	120.7±1.0	182±3.6
Silt (%)	36.1±3.35	45.8 ±1.81	62.3±1.70
Sand (%)	34.1±2.77	29.9±1.85	20.6±1.26
Clay (%)	29.8±2.15	24.3±1.77	17.1±2.08
WHC (%)	41.1±2.23	44±1.83	39.1±1.79
Texture Class	Clay Loam	Loam	Silt Loam

Table 4: Correlation coefficient of Physio-Chemical properties of soil with elevation.

Parameters	Correlation coefficient (r)
CaCo3 (%)	-0.990
pH	0.369
EC (µs/cm)	-0.095
OM	-0.989
SOC	-0.988
Silt (%)	0.9971
Sand (%)	-0.999
Clay (%)	-0.989
BD	0.916

Table 5: Correlation coefficient of Micro-Macro nutrients of soil

Parameters	Correlation coefficient (r)
Zn	0.995
Cu	0.999
Fe	-0.322
Mn	0.009
P	0.923
K	-0.181

Table 6: Analysis of Variance of Physio-Chemical properties of soil with the increasing altitude

	CaCo3	pH	EC	OM	SOC	Silt	Sand	Clay	BD
F-Value	5.23	13.29	66.43	1.95	5.69	45.52	34.18	27.48	60.00
P-Value	0.04	0.063	0.001	0.222	0.04	0.002	0.005	0.010	0.001
Significance	***	**	*	NS	***	*	*	*	*

*P<0.001, **P<0.01, ***P<0.05

Table 7: Analysis of Variance of Micro-Macro nutrients of soil with the increasing altitude

	Zn	Cu	Fe	Mn	P	K
F-Value	635.72	1161.46	36.36	26.00	249.61	50.05
P-Value	0.0000	0.0000	0.0004	0.001	0.0000	0.0002
Significance	*	*	*	*	*	*

*P<0.001, **P<0.01, ***P<0.05

Soil texture classes show clear difference with the difference in altitude (Table 3). Silt had significant correlation and variation with elevation it increases as the increase in altitude with the rate of correlation coefficient 0.997 at P<0.001 significance. (Fig 2 & Table 6) while the Sand and Clay shows negative correlation decreasing with the increase in altitude with the rate of correlation coefficient is -0.999 and -0.989 respectively at P< 0.01 significance. (Fig 3, 4 & Table 6) Elevation gain also seems to affect the soil texture and more correlation between soil chemistry and elevation. The previous work and present study suggested the organic matter decreased with increase in altitude reported by [3, 20]. It was reported that the bulk density depends on soil structure and texture, organic matter, freezing and thawing process [21,22].

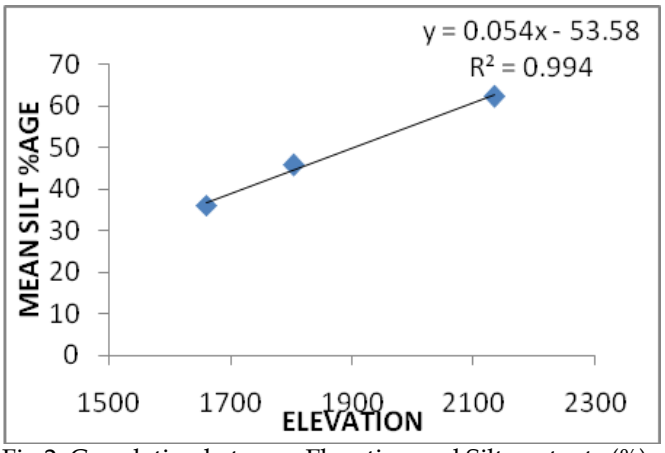

Fig 2: Correlation between Elevation and Silt contents (%)

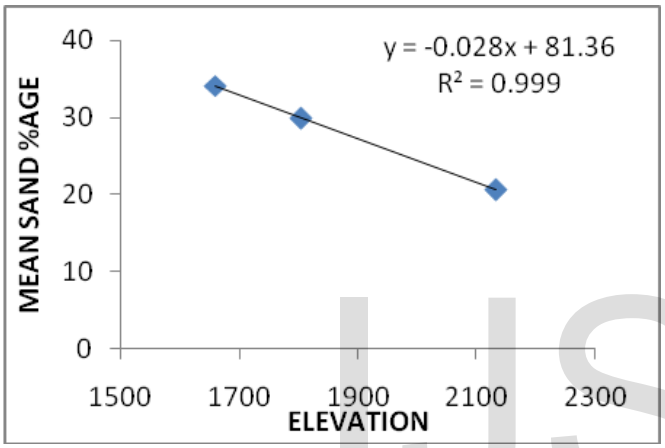

Fig 3: Correlation between Elevation and Sand contents(%)

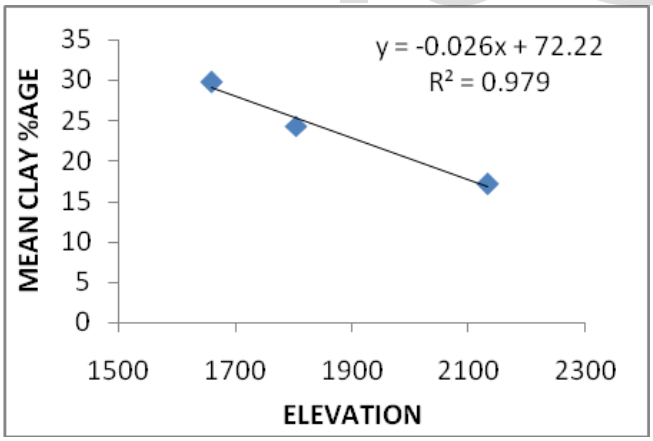

Fig 4: Correlation between Elevation and Clay contents (%)

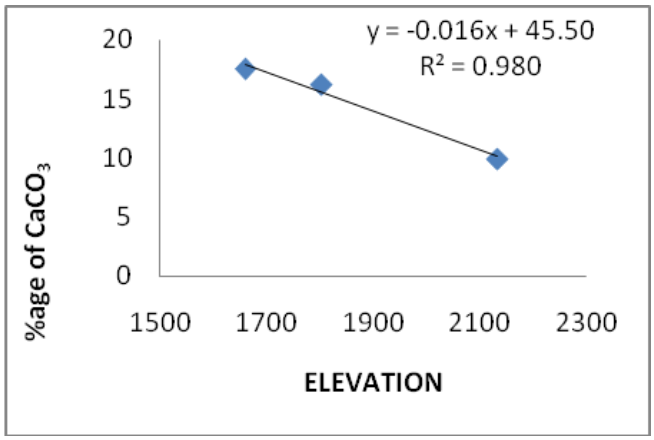

Fig 5: Correlation between Elevation and $CaCO_3$ contents (%)

Results of Micro-Macro nutrients revealed significant correlation with the altitude gradient that the percentage of available Zinc, Copper and Phosphorus content in the soil is increasing with the increase in altitude. (Fig 5, 7, 9 & Table 7). And the rate of correlation coefficient is 0.968, 0.873 and 0.827 respectively at P<0.001 significance. Available Phosphorus content were maximum at 2133m same were the results [20] at elevation 2216m show the maximum range which shows the elevation range with the our site elevation range.

Manganese, Iron and Potassium show some different pattern it increased at between the elevation that is 1804m with the rate of correlation coefficient is 0.009, -0.322 and -0.181 respectively at P< 0.001 significance. (Fig 6, 8, 10 & table 7). Potassium were recorded maximum at 1804m which was the approximately the same range of elevation as describe earlier by [20].

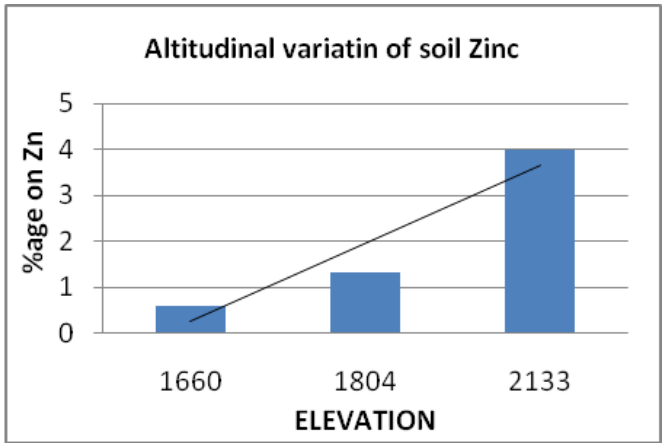

Fig 5: Altitudinal Variation of Available Zinc

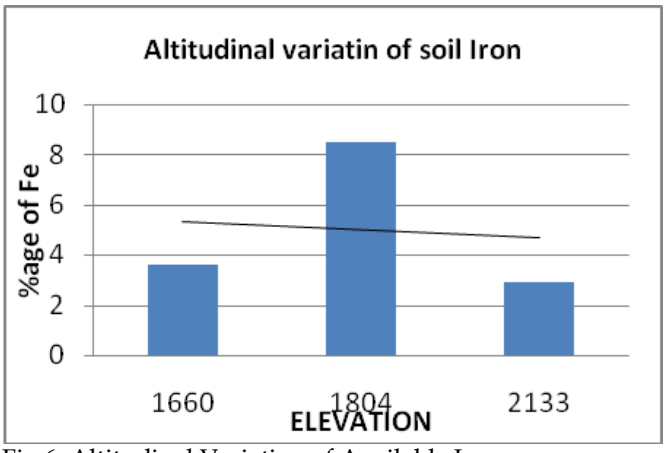

Fig 6: Altitudinal Variation of Available Iron

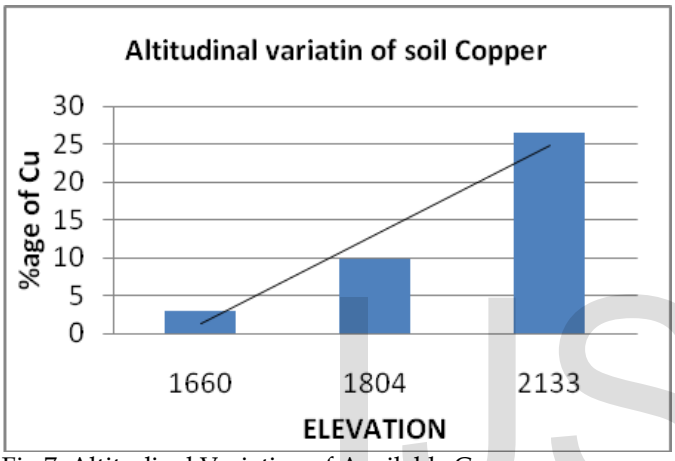

Fig 7: Altitudinal Variation of Available Copper

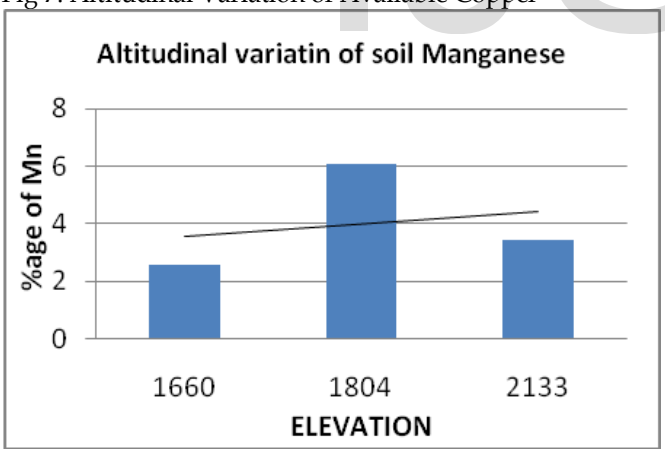

Fig 8: Altitudinal Variation of Available Manganese

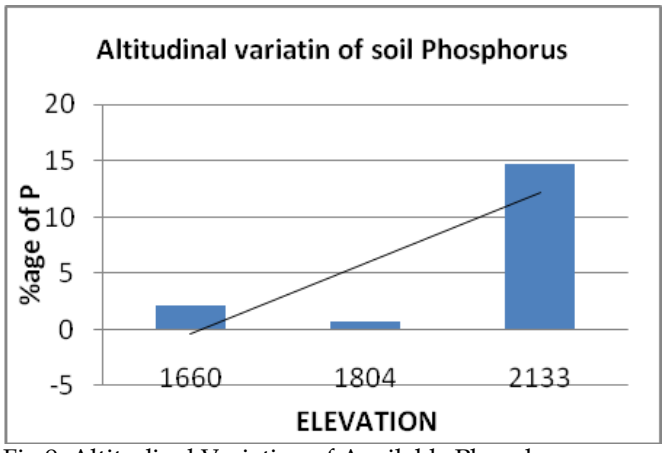

Fig 9: Altitudinal Variation of Available Phosphorus

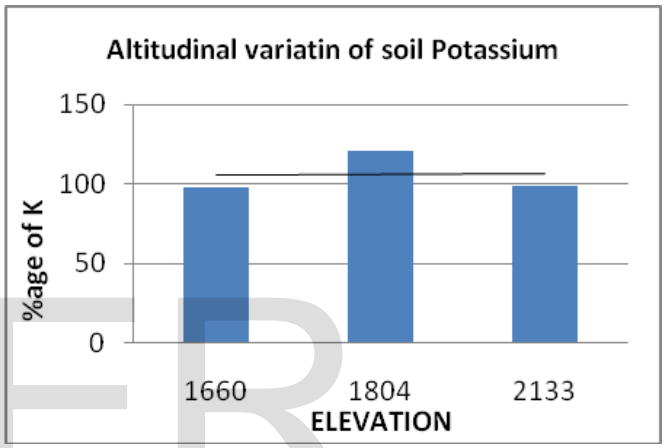

Fig 10:Altitudinal Variation of Available Potassium

4 CONCLUSION

This study results revealed that the changes in altitude had significant impact on certain physico-chemical properties of soil. The future trend of the study plays an important role in understanding the change in soil property effects on plant phytochemistry and genetic diversity of plants of the area.

5 ACKNOWLEDGEMENTS

Special thanks to Forest Department, Balochistan, Cameos Consultants, Soil & Water Conservation Dept. Arid Agriculture university. Rawalpindi and Soil Dept. Nuclear Institute Tandojam

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