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ALTITUDE EFFECT ON AVAILABLE MACRONUTRIENTS AND MICRONUTRIENTS PROPERTIES OF COLD ARID SOILS OF SPITI VALLEY IN HIMACHAL PRADESH

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ABSTRACT

To study the altitude effect on available macronutrients and micronutrients properties of cold arid soils of Spiti valley in Himachal Pradesh, Global positioning system (GPS) based surface (0-15cm) and subsurface (15-30 cm) soil samples were collected randomly using stainless steel spatula, shovel and spade. The surface, sub surface samples were analysed for available NPK, exchangeable calcium, magnesium and, available sulphur, boron and molybdenum; DTPA extractable Fe, Mn, Cu, Zn, Ni and Pb and physico-chemical properties *viz*. Soil pH, soil texture, bulk density, water holding capacity, electrical conductivity, organic carbon, cation exchange capacity, anion exchange capacity and $CaCO_3$ contents. The soils were found sandy loam to sandy clay loam in texture and slightly alkaline in their reaction (pH 7.7-8.1). Sand increased with increase in soil depth whereas silt and clay as well as other physico-chemical properties decreased with increasing soil depths. Electrical conductivity was found between 0.19-0.50 dS m^{-1}. Available N contents were in low category whereas, P and K were found in medium category. Exchangeable Ca and Mg, available B and DTPA extractable Zn, Cu and Ni were found in sufficient range whereas, Mo, Fe and Mn were deficient in Spiti soils.

KEY WORDS
Altitude
Effect
Macro
Micro

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INTRODUCTION

The Spiti valley with geographical area of 7,10,111 ha having extreme climatic and edaphic conditions falls in to the region with mean altitude of 4000 m amsl. Scanty rainfall, massive snowfall, high wind velocity, extreme temperature conditions from low to high, sparse vegetation, high UV radiation, intense solar radiation and extremely xeric conditions are the common features of this region (Devi and Thakur, 2011). Over the past decades, high altitude soils have attracted more attention in the debate on the potential impact of environmental changes on the global carbon cycle (Li *et al*., 1998; Oechel *et al*., 2000). Recently, increased pressure on agriculture sector to produce more grains and fodder in cold desert high altitude region has raised the concern on soil health and their management practices (Sharma *et al*., 2006). Soils at cold desert high altitude are coarse textured, permeable, deserted, and having poor water and nutrient holding capacity has low nutrient availability for growing crops and perform differently in the different soil types (Jobbagy and Jackson, 2000). The soils of Leh-Ladakh *i.e*. cold desert high altitude region are poor in mineral nutrients, wind erosion occurs on a mammoth scale and paucity of water is a perennial blockage (Bowman *et al*., 2002). Soil micro flora population is sparse due to poor soil structure, texture, very highs and and clay, low biological activity and freezing during long winter period in this region (Campbell and Claridge, 1987). The extremely high altitude of Himalaya probably provides a unique glacial climate on earth. In this area, sub zero temperature during maximum periods are responsible for different texture, mineralogy and very low soil development process indicating more advance stage of weathering. Altitude profoundly affects the soil's inherent fertility and runoff-erosion behavior (Bowman *et al*., 2002). Level of rainfall, snowfall, and temperature variation affects organic matter decomposition that affect accumulation of organic matter with elevation (Walker *et al*., 2000). These changes in microenvironment may affect physico-chemical characteristics of soil in this region hence the paper deals with the study on the effect of altitude on available macronutrients and micronutrients properties of cold arid soils.

MATERIALS AND METHODS

This study was designed with the objective to determine the altitude effect on available macronutrients and micronutrients properties of cold arid soils of Spiti Valley in Himachal Pradesh. The study area falls inextending between the latitudes 32°05′008″ N to 32°26′732″ N and longitudes of 077°45′744″ E to 078°06′636″ E. The surface (0-15 cm) and subsurface (15-30 cm) soil samples were analyzed for the properties *i.e*. soil texture was determined by rapid titration methods and water holding capacity as suggested by (Piper, 1950). Calcium carbonate was determined by Keen's box method as suggested by (Puri, 1930). Soil reaction by pH meter, electric conductivity (EC) by EC meter, organic carbon in soil was determined by Walkley and Black's rapid titration methods as suggested by Piper, 1966). Available N was estimated by using alkaline KMnO4 method as suggested by (Subbiah and Asija, 1956). Available P content of the soil was extracted with sodium bicarbonate by (Olsen *et al*., 1954). Cation exchange capacity, Exchangeable cations (Ca, Mg and Na) and available potassium by Neutral normal ammonium acetate extraction method suggested by (Jackson, 1967). Bulk density by Weighing bottle method suggested by (Lutz, J.F., 1947). Anion exchange capacity by 1N ammonium phosphate method suggested by (Sadana, 2007). Available Sulphur by Turbidimetric method as suggested by (Chesin and Yien, 1950). Available micronutrients (Zn, Fe, Cu, Mn, Ni, Pb) by DTPA Extraction as suggested by (Lindsay and Norvell, 1978). Mo by Ammonium Oxalate Extraction (pH 3.3) suggested by (Grigg,1953). Available Boron by Carmine method sa suggested by (Hatcher and Wilcox, 1950).

RESULTS AND DISCUSSION

Altitude effect on sand, silt and clay

The graphical representation of surface data of sand, silt and clay contents of the area against its elevation has been shown in Fig.1 A. This graph shows that the contents of sand and silt remained unaffected with the increase in elevation though sand tended to decrease a little at the altitude above 3800 m amsl. In contrast, clay content increased gradually with the increase in altitude from 3200 to 4600 m amsl. Similarly the data of subsurface soils (15-30 cm) was also plotted against the elevation (Fig. 1B). It revealed that sand content in subsurface soils increased gradually with the increase in altitude but silt and clay did not show any trend or little decreasing trend.

In present study altitude variation in clay and almost no variation in sand and silt contents was observed. Spiti soils of high altitude cold desert have been originated from weathered rocks. They are immature and have large proportion of sand, gravel and stone in them (Dwivedi *et al*.,2005) indicating the dominance of sand forming minerals in parent materials. Hence, our findings indicated that the cold arid soils are dominated by sand alike the hot arid soils, and this relative high proportions of sand in these soil fragments is causing sandy loam textural class in this region. Climate and parent material profoundly influence soil characteristics (Schinner,1982). Hence, the soils of studied region have more proportion of coarse grained soil particles, which indicates the slow process of soil formation. This may be due to the present climatic conditions *viz*. low temperature, higher snowfall, availability and movement of water along the altitude.

Higher silt but in general, lower sand proportion observed in our study indicates the presence of quartz, feldspars, hornblende, and micas in the soil (Ley *et al*., 2000). It is also assumed that the lack of smaller size particles shows the slow process of weathering in this region (Brady and Weil,1999). Therefore, slow process of soil formation along the altitude results in very low content of clay particles which may cause low content of available mineral nutrients in else soils (Kashyap *et al*., 2015).

Altitude effect on WHC, $CaCO_3$ and OC

The WHC, $CaCO_3$ and OC data of the surface soils of the Spiti valley when plotted against the elevation (Fig. 2A), it was observed that the values of WHC, $CaCO_3$ and OC increased with increase in elevation. This may be due to the increase in clay content with elevation. The similar graph of subsurface soil (15-30 cm) (Fig. 2B) showed that the values of WHC decreased a little with increase in elevation and the content of OC and $CaCO_3$ remain same. Soils at high altitude cold desert are coarse textured, permeable, deserted, having poor water and nutrient holding capacity and low nutrient availability for

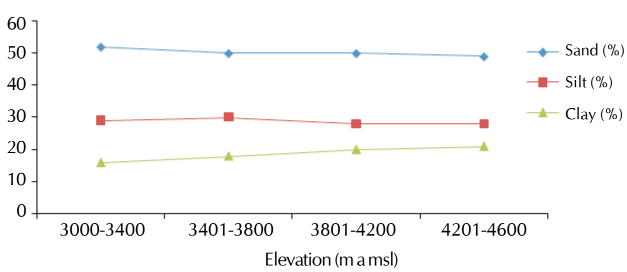

Figure 1(A): Altitude effect on sand, silt and clay in surface soils

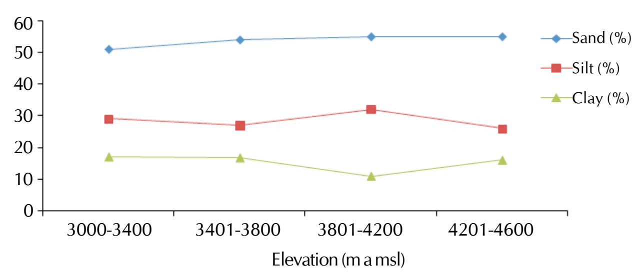

Figure 1(B): Altitude effect on sand, silt and clay in subsurface soils

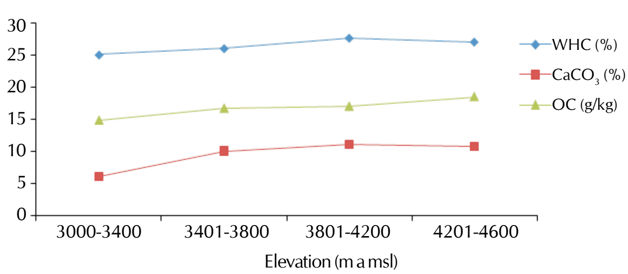

Figure 2(A): Altitude effect on WHC, $CaCO_3$ and OC in surface soils

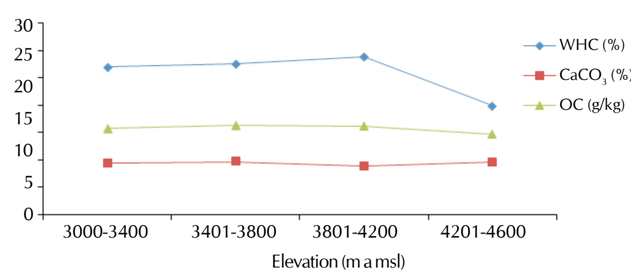

Figure 2(B): Altitude effect on WHC, $CaCO_3$ and OC in subsurface soils

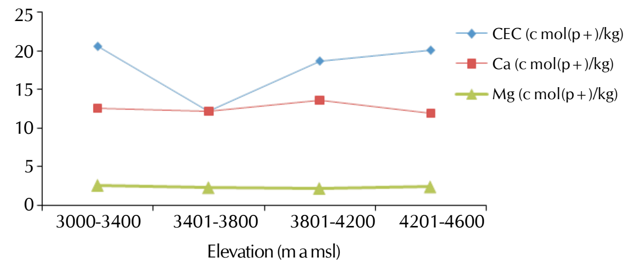

Figure 3(A): Altitude effect on CEC, Ca and Mg in surface soils

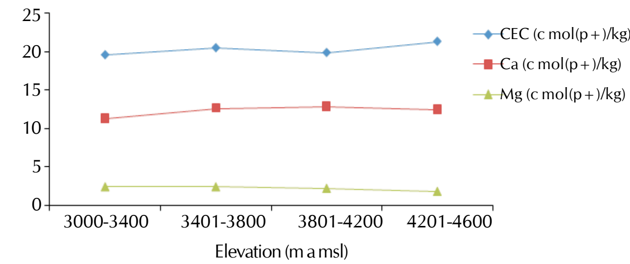

Figure 3(B): Altitude effect on CEC, Ca and Mg in subsurface soils

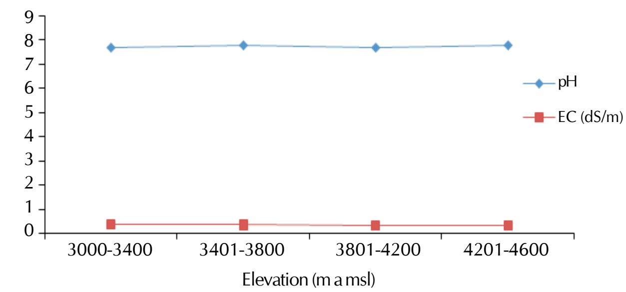

Figure 4(A): Altitude effect on pH and EC in surface soils

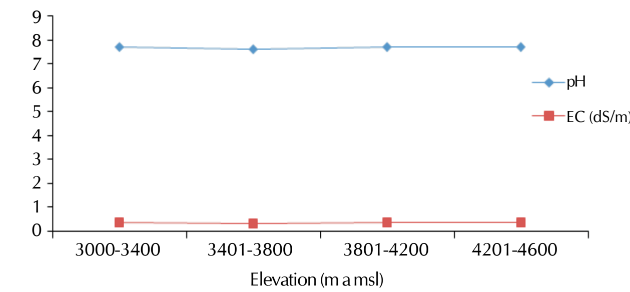

Figure 4(B): Altitude effect on pH and EC in subsurface soils

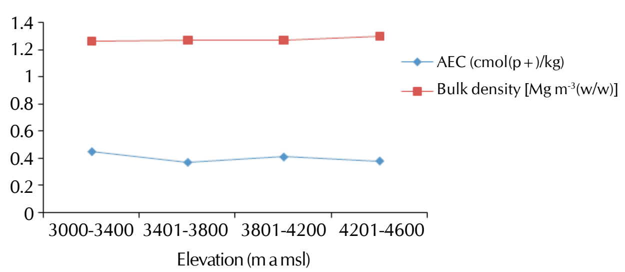

Figure 5(A): Altitude effect on AEC and Bulk density in surface soils

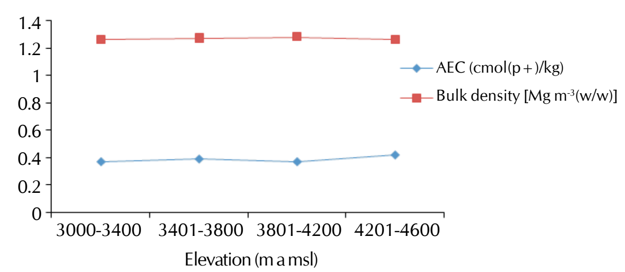

Figure 5(B): Altitude effect on AEC and Bulk density in subsurface soils

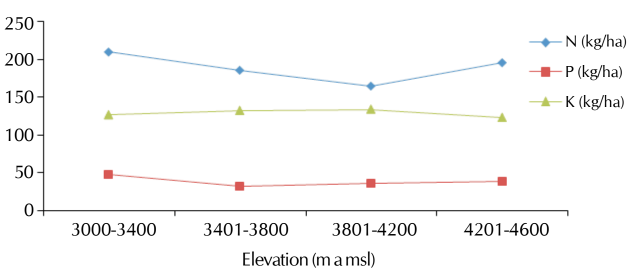

Figure 6(A): Altitude effect on N, P and K in surface soils

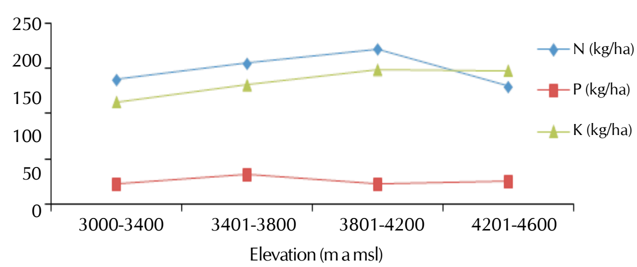

Figure 6(B): Altitude effect on N, P and K in subsurface soils

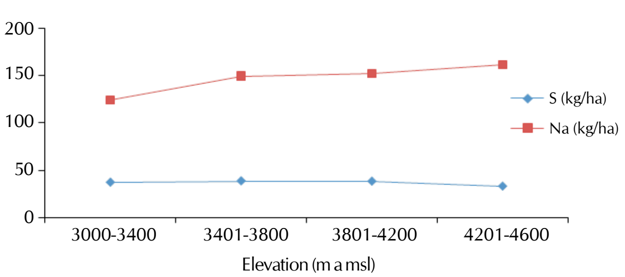

Figure 7(A): Altitude effect on S and Na in surface soils

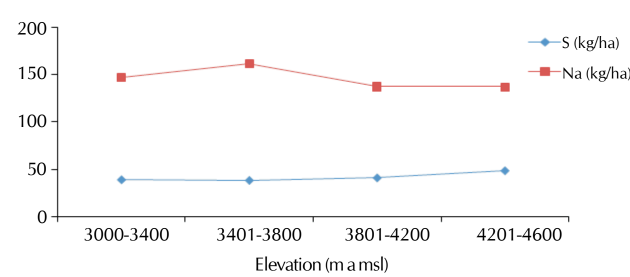

Figure 7(B): Altitude effect on S and Na in subsurface soils

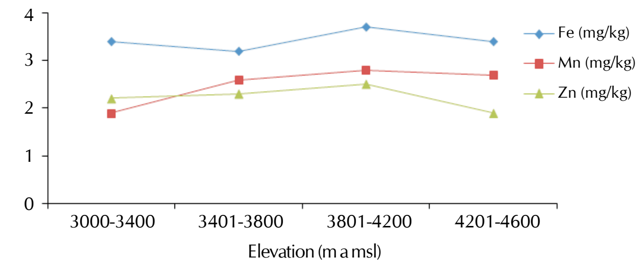

Figure 8(A): Altitude effect on Fe, Mn and Zn in surface soils

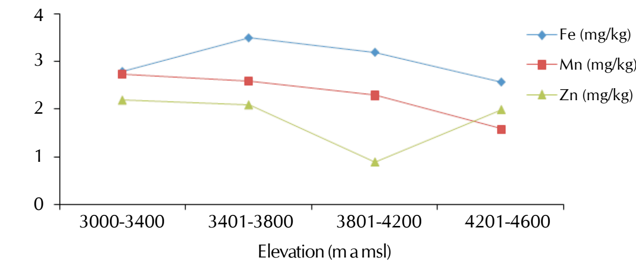

Figure 8(B): Altitude effect on Fe, Mn and Zn in subsurface soil

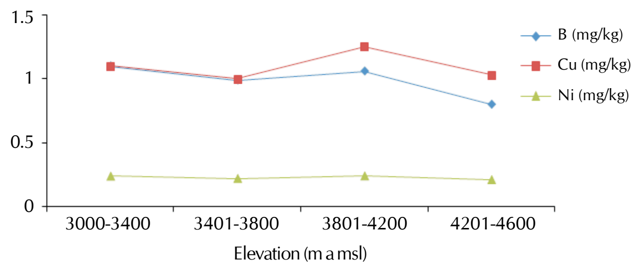

Figure 9(A): Altitude effect on B, Cu and Ni in surface soils

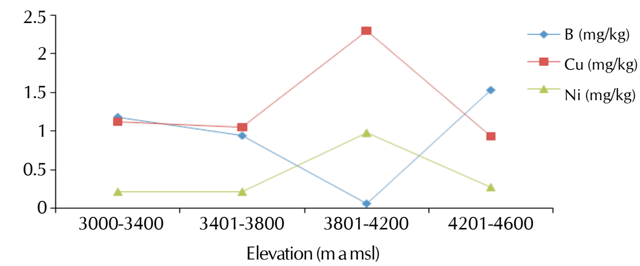

Figure 9(B): Altitude effect on B, Cu and Ni in subsurface soils

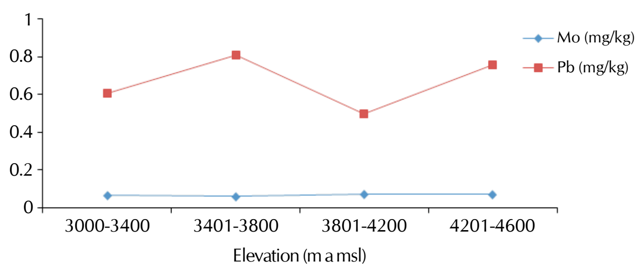

Figure 10(A): Altitude effect on Mo and Pb in surface soils

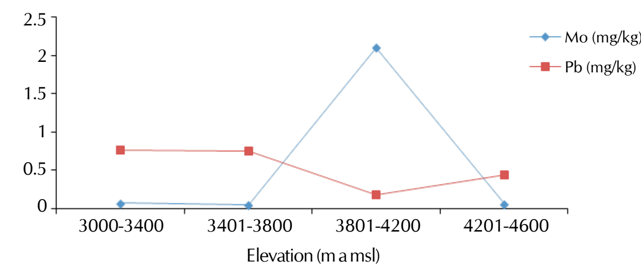

Figure 10(B): Altitude effect on Mo and Pb in subsurface soil

growing crops (Jobbagy and Jackson 2000, Dwivedi *et al.*, 2005 and Sharma *et al.*, 2006). This study indicated uniform high $CaCO_3$ content in Spiti valley. This might be due to low temperature and respiration rate and high snow precipitation at that altitude and type of the parent materials (calcite mineral in soil profiles) available there. Temperature affects $CaCO_3$ equilibrium directly through its influence on the solubility constant and indirectly through its effect on the partition of precipitation inputs between evapo-transpiration and leaching (Feng *et al.,* 2002).

Altitude effect on CEC, Ca and Mg

The graph of CEC, Ca and Mg against the elevation (Fig. 3A) showed that values of the CEC initially decreased up to the level of 3800 m amsl and as we go above this the values of CEC increased again to the same level whereas, Ca and Mg did not change much with the increase in altitude in the valley. Similarly, the data of these parameters in subsurface soils were also plotted against the elevation (Fig. 3B). It revealed that the values of CEC increased with increase in elevation but Ca and Mg did not show any trend. Level of rainfall, snowfall, and temperature variation affects organic matter decomposition that affects accumulation of organic matter with elevation (Walker *et al.*, 2000). These changes in micro-environment may affect physico-chemical characteristics of soil in this region. Many soil fertility characteristics (including organic matter content, pH, cation exchange capacity, phosphate sorption, and phosphorus availability) show significant altitudinal variations (Sharma *et al.*, 2009). Crop production and soil managements differ with kind of soil and their physico-chemical behavior (Mani,1990; and Sharma *et al.*, 2006).

Altitude effect on pH and EC

pH and EC values did not change with the increase in altitude from 3000 to 4600 m amsl in surface (0-15 cm) (Fig.4A) as well as subsurface soil (15-30 cm) (Fig.4B). These findings indicate that there is no major difference in cumulative salt accumulation along the altitude. These are in contrast to the finding of Northcott *et al.* (2009) who reported decreasing trend of pH and TDS from lower altitude (10000-11000 m amsl) to higher altitude showing that lower altitude sites having more cumulative salt accumulation than higher altitude sites. This may be due to the higher accumulation of base forming cations like Ca^{+2}, Mg^{+2}, $K+$ and higher accumulation of $CaCO_3$ at lower altitudes.

Altitude effect on AEC and bulk density

A graph between AEC and bulk density values of surface (Fig.

5A) as well as subsurface (Fig. 5B) soils and altitude of the area envisaged that both properties of soil remain unaffected with change in elevation from 3000 to 4500 m amsl. BD did not vary with the altitude that indicates similar nature of soil at all the altitudes. It was reported that the bulk density depends on soil structure and texture, organic matter, freezing and thawing process (Unger 1991 and Chen *et al.,* 1998). As these factors have no significant effect on soil to change their textural class in our study, bulk density did not change along the different altitudes.

Altitude effect on macronutrients and exchangeable Na

Altitude effect on N,P and K

Fig.6A showed that available N, P and K decreased with increase in altitude of the area. However, available N showed a little increase above the altitude of 4200 m amsl. The data of subsurface soils (15-30 cm) showed a reverse trend *i.e.* N and K increased with increase in elevation whereas, available P did not show any trend [Fig.6 (B)].

Altitude effect on S and Na

The available S went on increasing with increase in elevation from 3000 to 4600 m amsl whereas exchangeable Na did not get affected with rise in elevation though it showed a little decline above the elevation of 4200 m amsl [Fig.7(A). Similarly, in subsurface soils (15-30 cm) available S went on increasing with increase in elevation whereas exchangeable Na shows little increase above the elevation of 4200 m amsl (Fig.7 B).

Altitude effect on micronutrients and heavy metal

Fe, Mn and Zn

It is evident from the Fig.8 A that available Mn tended to increase with rise in altitude up to 4600 m amsl, whereas available Zn decreased with increase in elevation up to 4600 m amsl. Available Fe did not show any trend with change in elevation in subsurface soil (15-30 cm) whereas, the content of Fe, Mn and Zn decreased with increase in elevation [Fig.8 (B)].

Altitude effect on B, Cu and Ni

Graphical representation of available B, Cu and Ni contents against the altitude of the area (Fig.9 A) clearly indicated decreasing trend of Cu with increase in altitude whereas available B and Ni did not show any trend with increase in elevation. In subsurface soil available B, Cu and Ni did not show any trend with increase in elevation (Fig.9 B).

Altitude effect on Mo and heavy metal Pb

Available Mo content showed an increasing trend with increase in elevation (Fig.10 A) in surface soils and decreasing trend with increase in elevation in subsurface (Kanth and Kumar, 2009). (Fig. 10 B) soils. Whereas, DTPA extractable Pb did not show any specific trend with rise in elevation in Spiti valley.

Hence it is concluded that sand and silt remained unaffected with the increase in elevation though sand tended to decrease a little at the altitude above 3800 m amsl, whereas clay content increased gradually with the increase in altitude from 3200 to 4600 m amsl. However, sand content in subsurface soils increased gradually with the increase in altitude but silt and clay did not show any trend or little decreasing trend. Water holding capacity, $CaCO_3$ and OC in surface increased with increase in elevation. Available N showed a little increase above the altitude of 4200 m amsl. whereas subsurface soils (15-30 cm) showed a reverse trend *i.e.* N and K increased with increase in elevation whereas, available P did not show any trend. Available Mo content showed an increasing trend with increase in elevation in surface soils and decreasing trend with increase in elevation in subsurface soils, whereas, DTPA extractable Pb did not show any specific trend with rise in elevation in Spiti valley.

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