Executive summary

Soil is the fundamental constituent for plant nutrients and is affected by various components such as temperature, rainfall, altitude, aspect, vegetation cover, land use etc. This study was conducted to find the altitudinal variation of soil fertility in Langtang National Park (LNP) area. The soil samples were collected on April 2010 ad laboratory analysis was done immediately then after. Soil sample were taken from grazing lands almost at the rate of 500 meters variation in altitude in each sample around the trekking route starting from Syafru Bensi to above Kenjing Valley and brought to the laboratory for further analysis. Basic assumption we do have is that the soil fertility decreases with increase in altitude. The same hypothesis was proved by this study that the total nitrogen, available phosphorus, available potassium and organic matter decreased with increase in altitude.

Key words: Soil fertility, altitude, Langtang, Laboratory
Chapter I Introduction

1.1 Background

Soil, the outer most covering of the earth’s crust from which all dry land life draws its sustenance, is characterized by loosely arranged layers composed of organic and inorganic consistence constituents. The term soil is usually defined as a complex mixture of eroded rock, mineral nutrients’ decaying organic matter, water, air, and billion of living organisms, most of them are microscopic decomposers (miller, 1990). It supports all plants and animals life either directly or from other life that comes from the soil, and is itself produced partly through the effects of living thing. In soil formation, modification of parental mineral matter takes fairly a long time. Such a modification is actually the result of interaction of climatic, topographic and biological effects.

Social scientists have recognized six master social horizons and represented by capital letters O, A, E, B, C and R. The surface horizon is usually referred to as the O layer, consisting of organic matter. The remaining horizon (A, E, B, and C) are referred as mineral horizon and last, R is the horizon of hard bad rock. Forest soils consist of almost all six horizons where as agricultural soil lack O-horizon. The lacking of O-horizon is mainly due to the absence of fallen leaves and other biomass (Brady, 1984).

Any part of the earth’s surface that supports vegetation bears a covering of soil. Soil is thus defined as “any part of earth’s crust in which plants root.” The word “soil” is derived from a Latin word ‘solum’, meaning floor. Soil is the upper thin layer of earth’s surface derives from the weathering of rocks and minerals. Although soil is a potentially renewable resource, it is produced very slowly by the weathering of rocks, deposits of sediment by erosion and decomposition of organic matter in dead organism (Miller, G.T., 1999). It has also a biological system of living organic as well as some other components. It is thus referred to call it a soil complex, which has five categories of components viz, mineral, soil organic matter or humus, soil water (soil solution), soil atmosphere, biological system.
A soil has a certain distinctive physical, chemical and biological qualities which permit it to support plants growth. Soil chemical analysis is made to assess the available amounts of major nutrients, nitrogen phosphorus potassium and to assess a few other determinations which are correlated to soil fertility, such as soil texture, soil reaction (pH) and salinity.

**Soil Fertility**

The term ‘soil fertility’ is the quality of soil which sustains plants and helps them to grow well. It is a very significant quality of soil. It depends on many things such as soil texture, soil pH, nutrients, organic matter, water holding capacity, microorganism, structure, microclimate, irrigation facility, land fragmentations, soil erosion, agricultural system and practices, diseases and insects, consumption of nutrients by crops, conversion of nutrients into inconsumable by plants and gases, leaching of nutrients etc.

**Soil Organic Matter**

It is the solid portion of soil which is formed by the plants debris and dead animals. It increases humus in soil. Such matter increases activities of living population i.e. micro organism in the soil. This matter is useful to retain moisture in soil and to increase water-holding capacity in soil. The soils rich in organic matter contain much more microbial population than the eroded soil. The amount of organic matter in the soil is highly dependent upon the ecological zone in which it occurs as well as the land use and management of soil. Area under natural forest ha higher organic matter than these cleared for cultivation.

The soil is different with attitude. The soils in the terai region range from sandy loam to clay loam, and very from pale yellow to grey and brown in color. The soils are poor in nitrogen content, because in cropping pressure on the soils but contains adequate amount of potassium and phosphorous.

The mid hill soils are usually eroded and loaded with stone or sandy boulder and therefore the soil here is poor for agriculture. Soil in Kathmandu valley is of lacustrine type with top clay particles with organic matter.

The soils in the high mountains are of a shallow, stony, rocky, and glacial type. The PH of soil in Nepal is ranges from 4 in *Abies* forest to 8 in reverine. The most acidic soils in Nepal are
between 2500m and 3500m in the higher rainfall area. Agricultural lands have 6 to 7.5 pH value. At surface, it may be acidic and becomes alkaline at the bottom.

Plant synthesize many organic matter most of which return to the soil when they die and decay. Thus soil organic matter or the nutrients available to plant are found by the decomposition process is closely related to the decomposers, of which the most responsible are bacteria, actinomycetes, fungi, protozoan etc help to bring the soil fertility in decomposition of organic matter.

The surface soil is the most important part for the growth of vegetation. It is the storage of plant nutrient, air and water. It also helps in biological interactions and root activity. The supply of nutrients in the soil for plant growth is exhaustible. These nutrients are subject to continuous removal author through leaching, volatilization or erosion.

The soil environment plays an important role in agricultural activities. The agriculture is the mainstay of economy in Nepal providing livelihood for more than 80% of Nepalese population (Chaudhary et al. 1996). Introduction of modern clay agriculture requires heavy input of chemical fertilizers, pesticide, fungicides and herbicides. Traditionally farmers have been using compost. The compost is the best organic manure for the sustainable organic matter, improves soil water holding capacity.

1.2 Study Area

The study was implemented in Langtang National Park (LNP) and Buffer Zone, Nepal. LNP, spreading over 1710 km$^2$ (latitude: 27.86-28.39$^0$ N and longitude: 85.18-85.90$^0$ E) to the north of Kathmandu (at an aerial distance roughly 32 km), lies in the central Himalaya. The park experience distinct summer and winter seasons. From mid-April to mid-June, it is warm but often cloudy with occasional showers. Summer monsoon lasts until the end of September. The mean annual precipitation in the area is about 1000 mm and the mean annual temperature is 12.1$^0$C. LNP encloses the catchments of two major river systems: one draining west into the Trisuli River and the other east to the Sun Koshi River. Langtang itself is famous for its 108 lakes, the popular ones being Gosaikunda, Surya kunda, Bhairav kunda, etc. These wetlands are also famous for its religious values. The snowline in LNP lies at 5000 m above sea level (masl) while treeline is around 4500m (Chaudhary, 1998). There are many glacier lakes in the selected
area and the topography is relatively smooth, especially where a glacier lake culminates, otherwise most of the areas have canyons, steep cliffs and hanging valleys.

The complex topography and geology of LNP is associated with diverse climatic conditions and a wide spectrum of vegetation. LNP and surrounding regions include two major realms namely Indo-Malayan and Palearctic (DNPWC, 2008), thus representing area of high biodiversity value. This high altitude protected area has sheltered many native species that are adapted to the cool climatic conditions. The forest types in LNP range from sub-tropical to alpine tundra vegetation. Larix, Oak, Chirpine, Maple, Fir, Blue Pine, Hemlock, Spruce, many colorful flowering species like *Gentiana*, *Primula*, *Saxifraga* and various species of Rhododendron constitute the floral elements. This park accommodates significant faunal components like Snow Leopard, Red Panda, Musk Deer, Himalayan Tahr, many birds and butterfly species. A huge area of the park is covered with pastures, rocks, bare ground and snow/glaciers. The park is one of the three internationally recognized important protected areas for birds, and is also significant for the diversity of its mammalian fauna. In addition to its scenic and amenity values, the park features many cultural attributes including Gosainkunda. LNP is a well managed protected area where deforestation and habitat loss still remain insignificant; thus it was expected to provide good indicators of climatic impacts.

Tamangs constitute the major ethnic group in Langtang area. Tourism is one of the principal sources of income to local inhabitants. Thousands of Hindu devotees and Buddhists annually visit Gosainkund, a sacred lake inside LNP, during Janai Purnima Festival held in the month of September. Langtang valley is a paradise for trekkers where panoramic view of Langtang and Langsisa can be seen. Major trekking destinations in this region are Gatlang, Birdim, Rasuwa Gadi, Thulo Syabru, Singh Gomba, Gosain Kund, Langtang Valley, Kyangjin and many glaciers.

### 1.3 Objective

The broad objective of the study is to evaluate the altitudinal wise fertility variation of Langtang National Park (LNP).
The specific objectives are to analyze the nitrogen, phosphorus, potassium (NPK), organic matter and C:N ratio variation according to the altitude.

1.4 Rationale of the study

The depletion of nutrient level of the soil of Nepalese Himalaya is very common. Assessment of nutrient level of the area helps in the fertility management of different soil. The long term experiment plays an important role in understanding the complex interactions involving plants, soils, climate and management practices and their effects on plant productivity. Also, there is a basic assumption that the soil fertility decreases with increase in altitude. Therefore, this study was done to test the same hypothesis.
Chapter II: Review of Literature

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 (Lockeretz et al 1981, Warner 1997).

Increasing in soil organic matter following the transition to organic management occurs slowly generally taking several years to detect (Wander et al 1994). Yet can have a dramatic effect on long term productivity (Tiessen et al 1994).

Jha and Upadhyaya (1982) studied the relationship between climate, waterbalance and soil chemical composition of some selected station in terai region. The soil of that region was found to be poor in organic matter and nutrients. 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.

The hill forest development project (HFDP) - Kathmandu project area prepared a guide to assess the soil nutrients status for forestry soils of Nepal. It concluded that the soils, in general, can be considered infertile with consistently low available phosphorus levels (<4ppm); low-medium exchangeable potassium (0.1-0.2 meq/100gm) and low to high nitrogen (0.02-0.15%).
Chapter III Materials and Methods

3.1 Site selection
The study area was located at the Langtang National Park area. The soil sampling was done from eight sampling sites more or less with 500 m difference in altitude starting from 1278 m (the lowest point) to 4414 the highest point.

3.2 Sampling
The field visit was conducted at the mid of April 2010. The sampling of the soil was done in such a way that digging 15 cm in V-shape and mixing the soil from various depths in homogenous manner. The soil then was kept in a sampling bag, labeled well and then brought to the laboratory of Central Department of Environmental Science, Tribhuvan University.

3.3 Soil analysis
The composite soil samples were collected (1 sample) from each grassland. A single sample was taken from the each area by purposive sampling method. The samples were taken by digging a V-shaped pit of 3cm thick from surface. About 1 kg of composite soil samples from each site was kept in a polythene bag and made air tight and brought to the laboratory for further analysis.

a. Nitrogen (Kjeldahl Method):
Nitrogen in soil is present mostly in the organic form, together with small quantities of ammonium and nitrate forms. This method measures only organic and ammonium forms, nitrate is excluded.

i. About 1 gm of soil sample (passed from 2mm sieve) was taken in a round bottomed flask and 10 ml of distilled water was added in to it.

ii. The mixture was then left for half an hour.

iii. 20 gm of catalyst digestion mixture and 10 ml of conc. H\textsubscript{2}SO\textsubscript{4} were added into the mixture.

iv. Then the content was refluxed for one and half hour and cooled.

v. The mixture was then taken in a volumetric flask and volume will be made 100 ml using distilled water.
vi. From that volume 20 ml of sample was taken in a distillation flask and 20 ml of 40% NaOH was added into it. A few pieces of zinc was added into the distillation flask and swirled gently. This addition of zinc pieces helps in smooth boiling of the mixture.

vii. 50 ml of the sample from the volumetric flask was taken in a conical flask and 10 ml of 4% Boric acid and 2 drops of mixed indicator was added into it. The conical flask was then placed below the condenser so that the tip of the condenser should dip into the solution. Then the assembly was connected and distillation started.

viii. About 150 ml of condensate was collected and the flask was removed before heat caused back sucking.

ix. The mixed indicator in condensate turned blue due to the dissolution of ammonia. The content was then titrated with 0.1 HCl until the color changed to light brown pink i.e. the original color of the indicator.

x. Calculation:

\[
\% N = \frac{(a-b\times N \text{ of HCl} \times 1.4 \times V)}{(v \times s)}
\]

Where,

\[
\begin{align*}
    a &= \text{ml of HCl used with sample} \\
    b &= \text{ml of HCl used with blank} \\
    V &= \text{ml of total digest} \\
    v &= \text{ml digest distilled} \\
    s &= \text{wt of soil taken}
\end{align*}
\]

b. Available Phosphorus:

i. About 1 gm of soil sample was taken in a 500 ml conical flask and 200 ml of 0.002 N H$_2$SO$_4$ was added into it.

ii. The suspension was shaken for at least half an hour and was filtered to get a clear soil solution.

iii. Then 50 ml of filtered clear solution was taken in a clean conical flask and 2 ml of ammonium molybdate followed by 5 drops of SnCl$_2$ solution was added into it.

iv. When blue color had appeared reading will be taken at 690 nm on a spectrophotometer using distilled water blank with the same amount of chemicals.
The reading should be taken after 5 minutes but before 12 minutes of the addition of the last reagent.

v. Then the concentration was calculated with the help of standard curve.

c. % Carbon and Organic Matter (Walkey and Black Method Modified)
   i. Oven dried or freeze dried soil sample was taken and passed through a 0.5 mm non ferrous screen.
   ii. About 1 g of soil sample was weighed and transferred to a dried 500 ml conical flask.
   iii. 10 ml of 1 N \( \text{K}_2\text{Cr}_2\text{O}_7 \) and 20 ml of conc. \( \text{H}_2\text{SO}_4 \) was added and mixed by gentle swirling.
   iv. The flask was allowed for the mixture to react and will be kept for about 30 minutes.
   v. After the reaction will be over, the content was diluted with 200 ml of distilled water and then 10 ml o-phosphoric acid was added followed by 1 ml of diphenylamine indicator.
   vi. The sample was then titrated with 0.4 N Ferrous Ammonium Sulphate (FAS) till the color changed to brilliant green at the end point.
   vii. The process was repeated for blank with same quantity of the chemicals but without soil.
   viii. Calculation:
      a. \( \% \text{ Carbon} = (1-T/S)(3.951/g) \)
      b. \( \% \text{ Organic Matter} = \% \text{ Carbon} \times 1.724 \)

Where,

\[ g = \text{wt. of sample in g} \]
\[ S = \text{ml of FAS with blank titration} \]
\[ T = \text{ml of FAS with sample titration} \]

The factor 1.724 is based on the assumption that carbon is only 58 % of the organic matter.
d. **Potassium content**

Exchangeable K is determined in ammonium acetate following flame photometer method by using the following reagents:

a) Ethyl alcohol 40% b) Absolute alcohol c) Ammonium acetate solution (1N)

50g of air dried soil was taken in 500ml beaker and added about 100ml of 40% alcohol. It was shaken well and kept for 15minutes. The suspension was filtered through Whatman no. 50 filter paper using Buchner funnel and vacuum pump. The soil was washed 4-5 times with 50ml portion of 40% alcohol. The final washing was performed with 50ml of absolute alcohol to dry the soil. The filter paper was removed and scraped the soil in 250ml beaker. The Buchner funnel and filter paper was washed with 100ml ammonium acetate solution for removing any adhered portion of the soil. The soil extract was prepared by leaching with 1N ammonium acetate solution and the suspension was filtered and finally filtered the soil, with additional ammonium acetate through Whatman No. 42 filter paper using Buchner funnel and vacuum pump. The soil was leached 4-5 times with more ammonium acetate and the final volume of the filtrate was made upto 500ml in a volumetric flask.

The concentration of K(or Na) is find out by following photometric method.

\[
K\% = \frac{mg\ K/L\ of\ soil\ extract \times V}{10000 \times S}
\]

\[
K,\ mg/100mg = \frac{mg\ K/L\ of\ soil\ extract \times V}{10 \times S}
\]

\[
K,\ meq/100g = \frac{mg\ K/L\ of\ soil\ extract \times V}{10 \times S \times 39}
\]

where, \( V= \) total volume of soil extract prepared(500ml)

\( S= \) Weight of taken soil ( 50g)

It was measured by flame photometer method, PCARR(1980)
e. **C:N ratio**

C:N ratio was calculated from the values of organic matter and nitrogen%.

C:N ratio = organic matter(%)$/1.7 \times$ nitrogen(%). (Trivedi and Goel, 1986).
Chapter IV Results

4.1 Total Nitrogen

The percentage of total nitrogen content in the soil is decreasing with the increase in altitude. The rate of correlation coefficient between the altitude and the total nitrogen content is -0.962 which indicates that the nitrogen content is strongly negatively correlated to the altitude.

![Altitudinal Variation of Soil Nitrogen](image)

Fig: Altitudinal Variation of Soil Nitrogen

4.2 Available Phosphorus

The percentage of available phosphorus content in the soil is decreasing with the increase in altitude. The rate of correlation coefficient between the altitude and the available phosphorus content is -0.2751 which indicates that the Phosphorus content is poorly negatively correlated to the altitude.

![Altitudinal Variation of Available Phosphorus](image)

Fig: Altitudinal Variation of Available Phosphorus
4.3 Available Potassium

The percentage of available Potassium content in the soil is decreasing with the increase in altitude. The rate of correlation coefficient in between the altitude and the available Potassium content is -0.7927 which indicates that the potassium content is highly negatively correlated to the altitude.

![Altitudinal Variation of Available Potassium](image)

Fig: Altitudinal Variation of Available Potassium

4.4 Organic Matter

The percentage of organic matter content in the soil is decreasing with the increase in altitude. The rate of correlation coefficient in between the altitude and the organic matter content is -0.6612 which indicates that the organic matter content is fairly negatively correlated to the altitude.

![Altitudinal Variation of Soil Organic Matter](image)

Fig: Altitudinal Variation of Soil Organic Matter
4.5 C:N Ratio

The C:N ratio is increasing with increase in altitude that is the rate of percentage decrease of nitrogen is higher than that of organic matter.

Fig: Altitudinal Variatio of C:N Ratio
Chapter V Conclusion

The soil fertility of the Langtang National Park (LNP) decreases with increase in altitude. The sharp decrease has been found for the percentage of nitrogen content followed by available potassium percentage and organic matter content.

The above result is compatible with the hypothesis that the soil fertility decreases with increase in altitude.

The soil fertility depends upon the various factors like vegetation, land use pattern, climate, aspect etc. Since, the area is of high altitude area so in high lands the organic matter and other fertility parameter are very low.
Reference


Annex I

Data Tables

1. Altitude Vs soil fertility

<table>
<thead>
<tr>
<th>Altitude (m)</th>
<th>N (%)</th>
<th>Available P (%)</th>
<th>Available K (%)</th>
<th>OM (%)</th>
<th>C:N Ratio</th>
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<td>0.0245</td>
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2. Altitude Vs C:N Ratio

<table>
<thead>
<tr>
<th>Altitude (m)</th>
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<td>6.122449:1</td>
</tr>
<tr>
<td>2216m</td>
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</tr>
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<tr>
<td>4414m</td>
<td>8.823529:1</td>
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Annex II Photographs

Pic 1: A snap of a sampling site

Pic 2: Laboratory analysis of soil samples