Influence of Soil Properties and Environmental Variables on Plant Communities in Lake Naivasha Drainage Basin; Kenya

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ABSTRACT

The vegetation around Lake Naivasha is under great threat by the horticultural and livestock farming common in the region through irrigation practices and overgrazing. The vegetation is heterogeneous varying from aquatic plants, grassland, shrubland, woodland and a forest. The study was conducted to analyse the effect of soil properties and environmental variable on plant communities. A total of 227 plant species were collected and identified representing 65 families. Plant species were classified into five community types using Hierachical Agglomerative Clustering Technique of the Syntax computer programme. These were: *Acacia brevispica - Acacia drepanolobium* community, *Acacia xanthophloea–Pennisetum clandestinum* community, *Euphorbia candelabrum-Euphorbia buseii* community, *Digitaria abyssnica-Eragrostis superba - Sida cuneifolia* community, and *Tarchonanthus camphoratus- Solanum incanum* community. Soil samples collected from each sample plot were analysed for soil pH, electrical conductivity, cation exchange capacity, organic matter, sodium, potassium, calcium, magnesium, phosphorus, nitrogen and soil texture (sand, clay and silt content). Plant species diversity and richness decreased with distance from the lake as the woodlands and shrublands vegetation types near the lake had high plant species diversity than the grasslands. The results support the prediction that species diversity and richness decrease with increase in habitat degradation. Recommedations towards the conservation of plant species diversity around Lake Naivasha area are also put forward.

Introduction

The unprecedent levels at which countless known and unknown species are being lost due to habitat modification and fragmentation has led to what many scientists believe is a bio-diversity crisis (Wilson, 1985 & 1992; Wilson and Peter, 1988). The biotas of little studied areas (developing countries for example) are poorly known and the ranges of most species, even in developed countries, are not adequately documented (WCMC, 1992; Pimm and Gittleman, 1992). Similarly, distributional information is generally available for charismatic taxa such as large herbivores, birds and few plant species but distributional and diversity information of most taxa are anecdotal at best (MacArthur, 1972).

One of the habitats severely affected because of human influence is savannah woodland. This vegetation type covers most of sub-Saharan Africa and supports diverse plant species. These ecosystems are increasingly being affected by human settlement and expansion of human land use mainly agriculture and trees logging (Whittaker, 1970; 1975; Grandin, 1991; Crawley, 1997). Disturbance in the form of removal of trees from a vegetation community can reduce bio-diversity and modify the structure of the eco-system (Huston, 1994). Fires, human activities and large herbivores may cause such removal (Crawley, 1997)

Prior to human population explosion and advances in technology, man lived in near balance with the environment (Frost *et al*., 1986; Grandin, 1991). Although a lot has been documented on effect of stochastic events to the environment and biodiversity in general (Skarpe, 1992; Rodgers, 1995), little is known on how current population explosion, urbanization, advances in technology and industrialization have caused natural habitats modification and fragmentations. This is mostly due to the fact that modern man has become self-centered aiming at capitalization and advancement with less concern about the environment. In order to develop policies and strategies for the conservation and management of the world's dwindling biological resources, it has been realized that there is an urgent need to survey and document these resources as a first step towards minimizing their loss (Crawley, 1997).

The study of plant communities' diversity and distribution in Lake Naivasha drainage basin, is one among many suggested studies that need to be conducted, to contribute to the documentation and analysis of the most important biological resources in Kenya that need to be conserved. We believed that the data obtained from this study will help in decision-making by the authorities concerned with conservation issues in Kenya. The objectives of this study were; to identify plant species diversity; analyse the plant communities around Lake Naivasha; and determine the effect of soil properties and environmental variables on plant communities.

Material and methods

Study Area

Lake Naivasha is approximately 150 km^2 in total area (Harper *et al.,* 1990). It lies on the floor of the Eastern Rift valley at a mean altitude of 1890 m a. s. l, Latitude $0^0 45'$ to 00^0 56' South and Longitude $36^0 22'$ to 36^0 54' East (LNRA, 1993).

The area is semi-arid; receiving an average rainfall of 620 mm each year (LNRA, 1993) while annual evaporation is approximately 1735 mm. The rainfall trend is bimodal, with a major peak in April – May and a minor one in October – November. The higher rainfall in the elevated regions of the catchments (i.e. Aberdare Ranges and Kinangop Plateau) partly offsets the annual deficit through the Malewa River discharge (LNRA, 1993). The mean monthly temperature is almost uniform ranging from 18^0c – 30^0c, and the mean annual temperature is around 26°c. There is quite a big diurnal variation and a definite cold season as a result of cold air coming down from the Nyandarua Ranges.

The vegetation is heterogeneous varying from aquatic plants such as papyrus around the lake margins, sub-merged macrophytes, grasslands, bush land, woodland and forest. Generally, savannah vegetation is predominant (Harper, 1990). The vegetation types and distribution patterns are strongly associated to soil type that in turn is associated to topography (Watson & Parker, 1970; Harper, 1990). Other factors that influence the vegetation types include the level of water table, herbivory or selective feeding, trampling and human disturbances such as deforestation and farming (LNRA, 1993). Rainfall, soil and topography influence plant species diversity in the region most, among other abiotic factors. Soils in the catchment area are generally developed from volcanic activity, and are of moderate to low fertility, deep clayish loam, greyish, brown to black in colour, often with poor drainage. The soils often degenerate into black cotton soils with impeded drainage in low-lying areas (Harper, 1990).
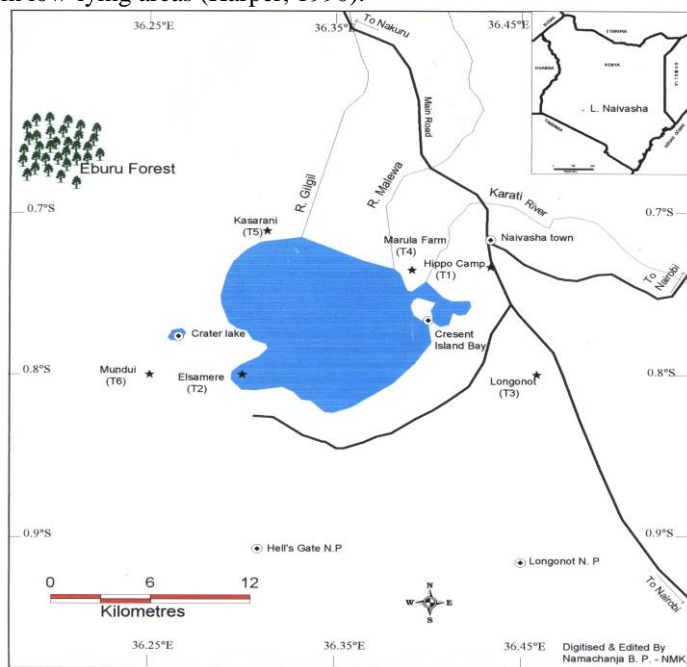
Figure 1: Map of the Study Area showing the five study sites (T1- T6)

Data Collection
Vegetation Data

A total of 6 transects namely T1 – T6 were established (figure 1). Each transect extends from the lakeshore to the dryland and the length of each transect depended on the vegetation types encountered. Vegetation sampling was done using nested plot technique as described by Muller-Dumbois and Ellenberg (1974). Sample plots of (1 m x 1m) were used for herbs and grasses, (5 m x 5 m) plots for shrubs and herbs and (20 m x 20 m) plots for trees. Trees were identified as plant taller than 5 m in height and with a single stem/bole from the ground.

A total of 56 sample plots were analyzed throughout the study area from the six transects. Sample plots 1-5 and 16-20 were laid along T_1 (Hippo camp), sample plots 6-10 and 21-25 were laid along T_2 (Elsamere/ Hell's Gate N.P), sample plots 11-15 and 26-30 were laid along T_3 (Longonot), sample plots 31-40 along T_4 (Marula farm), sample plots 41-48 were laid along T_5 (Kasarani/ Eburu) and sample plots 49-56 along T_6 (Mundui). In each sample plot, all the plant species that were present were recorded and estimated for percentage cover. Those that could not be identified in the field were collected, pressed properly, and taken to the East African Herbarium, National Museums of Kenya for identification. Voucher specimens were also collected and taken to the East African Herbarium, in Nairobi, for further identification and verification. The identification and naming of the plant species was based on the published taxonomic work such as flora of Ethiopia, Flora of Tropical East Africa (Thulin, 1989; Townsend, 2000; Hedberg, 2000; Vollesen, 1989; 1995; Gilbert, 1995), and available herbarium specimens.

Each plant species in each sample plot was assigned a cover /abundance value following a 1-9 Braun -Blanquet cover/ abundance scale, as modified by Van der Maarel (l979) as follows: any number of individual with a cover more than 75% of plot area was given a scale of 9, those with 50% - 75% a scale of 8, 25% - 50% a scale of 7, very abundant but with less than 25% cover a scale of 6, 12.5-25% a scale of 5, 5%-12% a scale of 4, less than 5% a scale of 3, few individuals a scale of 2 and the rare species a scale of 1.

Soil Sampling and Analysis

At each sample plot, soil samples were collected from a depth of 0-15 cm using soil auger. The soil samples were sealed in paper bags to prevent contamination, and transported to the laboratory for analysis of physical and chemical properties. Exchangeable Bases –Sodium and Potassium were determined by flame photometry method as described by Page (1982) and Allen (1989) and readings were taken as $cmol/kg^{-1}$. Calcium and Magnesium were determined using atomic absorption spectrophotometry method as described by Page (1982). Cation Exchange Capacity (CEC) – was determined by simplified semi-micro schollenberger's method as described by Okalebo & Gathua (2003). Soil pH - pH was determined electrometrically using electrometric method, at a ratio of 1:2.5 v/v (soil water suspension) as described by Gapta (1999). Soil Texture-The percentage of sand, clay and silt was by hydrometer method (Juo, 1978). Electrical Conductivity (EC)-was analysed electrometrically as described by Juo (1978) and Gapta (1999). Organic Matter-was done using the Walkley-Black method and recorded as % dry weight (Allen, 1989; Gapta 1999). Total Nitrogen was determined by the use of Kjeldahl method to convert organic Nitrogen to Ammonia and then Indophenol's blue method was used to determine amount of Ammonia that gives the percentage of Nitrogen content. Readings were taken as % Nitrogen (Juo, 1978). Phosphorus- was determined using Bray No.11 method and readings recorded as $cmol/kg^{-1}$ as described by Okalebo and Gathua (2003) and Gapta (1999).

Environmental Data

Altitude, latitude, and longitude at each sample plot were recorded using GPS (Geographical Position System). The degree of trampling and herbivory were visually estimated in each sample plot, with 1-4 points scale as follows: 1, denoted no trampling or grazing effect; 2, denoted trampling and/or herbivory effect was less (with no cause of damage to plants); 3,

denoted there was moderate trampling and herbivory effect; 4, denoted severe damage to the plants by trampling and herbivory.

Data Analysis

The plant species diversity and evenness were calculated using Shannon and wener diversity index using the formular

$H'=-\sum Pi \times LogPi$, where $Pi=ni/N$; while species evenness indices was used to calculate evenness (Magurran, 1988). Plant community types were analysed following the hierachical agglomerative clustering technique of the computer programme SYNTAX (Podani, 1988). Similarity ratio was used as a resemblance index and avarage linkage was used as the clustering technique. The relationship between environmental variables were analysed using Pearson's product – moment correlation coefficient available in the statistical anlysis systems using the computer program SPSS (Statistical Package for Social Sciences vs 11.

Results

Vegetation Classification

A total of 227 plant species that belonged to 65 families were collected and identified from the study area. The classification results show that there were five plant community types formed by these plant species. The dendrogram produced by Syntax computer output shows the different sample sites forming the distinct community types against the similarity ratio of scale ranging between 0 - 0.9. Five major community types were identified and designated as I, II, III, IV, and V (figure 2). Plant communities were named by use of the dominant plant species within each group. One or more plant species with the highest mean cover- abundance value, were used in naming the plant communities (Whittaker, 1975).

Figure 2. Dendrogram of sample stand groups of vegetation around L. Naivasha. Y-axis represents the dissimilarity level and X-axis represents sample plots.

Plant Species Diversity, Evenness and Richness Between Five Plant Community Types

The data of plant species diversity (H'), evenness (E) and richness (N) of the five plant community types are indicated in Table 1. Community type II, IV and V show high species diversity and richness while community type I and III had low species diversity and richness. The plant species found in sample plots that belonged to community type I and III were in most cases homogeneous whereby one or few plant species dominated a vegetation type.

Table 1. Comparison of Plant Species Diversity, Evenness and Richness Between Five Plant Community Types. (Different letters in each row indicate significant difference at p≤ 0.05 while same letters show no significant difference)

	Plant Community Types			
	I V	II	III	IV
Species Diversity	0.48a 0.79d	0.41b	0.57c	0.43b
Species Evenness	0.65a 0.69a	0.78b	0.59c	0.89d
Species Richness	46a 49a	76b	14c	42d

In comparing species diversity and evenness in the different communities analysed, results show that community I, III, IV and V have both significant high diversity and evenness at p< 0.05. Community type IV is significantly evenly distributed than other plant community types. In terms of species richness, plant community I, II and V show significant high number of species.

The study area was found to have diverse species composition that were represented by 65 families (Table 2). A total of 227 plant species were identified in the study area. More than 40 % of the plant species encountered, belonged to 6 families only (table 1). The highest number of species belonged to the family Poaceae with 11.5% of the total number of species, followed by Asteraceae 9.7%, Fabaceae 7.48%, Lamiaceae 7%, Amanthaceae 3.9% and Acanthaceae with 3.1 %.The total number of species in each family ranged between one species to 26 species (table 2).

Table 2 : Ten Familes with the Highest number of Plant Species

Family	No. of Species	% Frequency
Acanthaceae	7	3.1
Amaranthaceae	9	3.9
Asteraceae	22	9.7
Crassulaceae	5	2.2
Cyperaceae	6	2.6
Fabaceae	17	7.48
Lamiaceae	15	7.0
Rubiaceae	4	1.8
Scrophulariaceae	5	2.2
Poaceae	26	11.5

Correlation Between Plant Communities and Environmental Variables

In order to obtain the relation between the community types and environmental variables, Tukey family error test was performed. Community types show significant variations with respect to all the environmental variables except with sand, magnesium and organic matter

The results show that plant community type III and IV were found in areas which had high sand content in the soil, while community type I, II and V was found in areas which had low sand content in the soil. Community type II and V on the other hand dominated areas with high clay content in the soil. *Acacia*
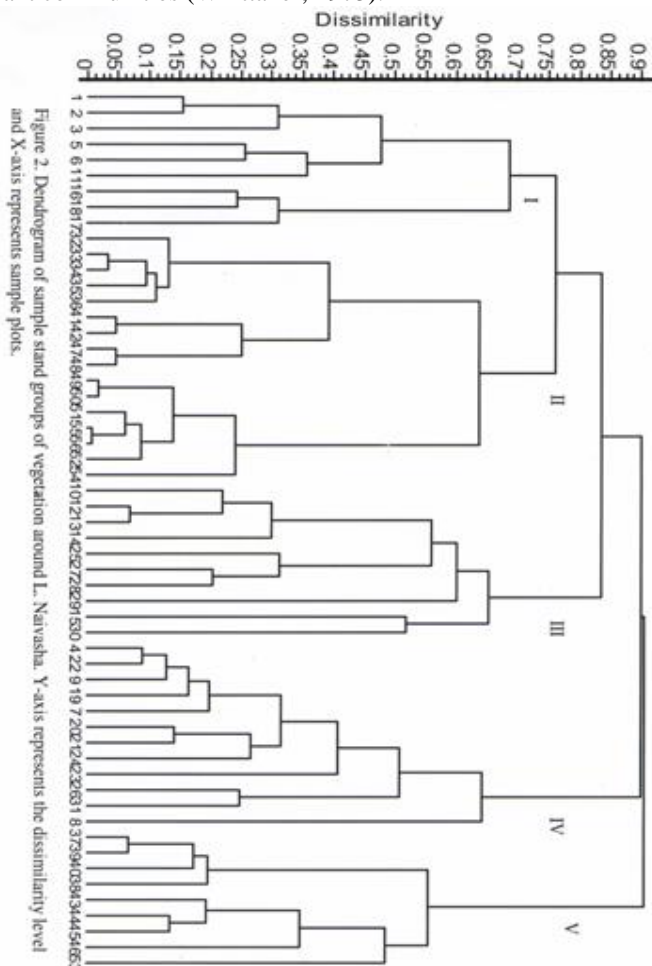
xanthophloea woodland and *Pennisetum clandistenum* grassland dominated the lowlands near the lake with high clay content in the soil. With respect to soil pH, plant community types II and III had pH value greater than 7.5, while community types I and IV had pH value less than 6.5. In the lowlands near the lake, the soil pH is lower than in the areas far away from the lake. It has been argued that most plant flourish well in a pH of 6.5 which is also the optimum pH for many microbial activities. Very low and very high pH interferes with the decomposition of organic matter by micro- organisms thus limiting the supply of nutrients to the soil.

With respect to organic matter content plant community types I and II were found in areas with high organic matter content, while community types III and V were in areas with low organic matter content in the soil. Community types I and II represent the woodlands and wooded shrubland while community type III and IV are grasslands. Trees leaf litter contributed highly to the content of organic matter in plant community I and II. Trampling and herbivory was found to be very high in community type I and lowest in community type III and IV.

Table 3: Tukey Family Error Rate Test Between Plant Community Types And Environmental Variables. (Different letter notations in each row indicate significance difference at p>0.05 while different letters show no significance difference)

Environmental Variables	Plant Community Types				
	I	II	III	IV	V
Calcium	4.9b	2.2c	1.5c	5.2a	2.2c
Herbivory	3.0a	2.2c	2.1c	2.5b	1.7c
Trampling	3.0a	2.2b	2.2b	2.3b	1.5c
PH	6.3c	7.9a	7.1b	6.4c	7.6a
E C	0.27b	0.32a	0.21b	0.31a	0.3a
Nitrogen	0.14b	0.15b	0.18b	0.19b	0.48a
Organic matter	32a	26.7b	17c	25.4b	24b
Sodium	1.7a	1.8a	0.8b	2.3a	1.0b
Pottasium	4.7a	3.4b	1.4c	1.8c	2.1c
Magnesium	2.2b	2.4b	2.8a	1.8b	3.3a
Phosphorus	19.2c	27.4a	22.4b	24.8b	29.8a
CEC	20.8a	13.9b	13.7b	14.5b	16a
Silt	74.3a	37.6c	46b	54.9b	67.5a
Sand	16a	15.6b	16.5a	17.3a	15.3b
Clay	28.2b	29.2b	28.6b	28.7b	46.8a

Discussion

Plant community types :

Community type I - *Acacia xanthophloea – Pennisetum clandistenum* community

Acacia xanthophloea dominated this community type. This community occured mainly as Acacia woodland near the lake. *Acacia xanthophloea* was the dominant tree layer, while *Pennisetum clandistenum* constituted the ground cover. Another plant species that was closely associated with this community type was *Pennisetum squamulatum*. The presence of grasses as dominant species in the lower canopy outcompeted the growth of herbs and shrubs that were found to be very rare.

Community type II - *Tarchonanthus camphoratus- Solanum incanum* community

This community type is characterised by *Tarchonanthus camphoratus* as the dominant shrub. *Solanum incanum* was the common herb in this community. Grasses such as *Digitaria milanjiana*, *Chloris gayana* and *Conyza newii* were also present. Other species associated with this plant community are *Justicia lorata*, *J. flava*, *Ocimum suave*, *Prunus africana* and *Polygala sphenoptera*.

Community type III – *Digitaria abyssnica-Eragrostis superba- Sida cuneifolia* community

This community is mainly dominated by *Digitaria abyssnica*, *Eragrostis superba* and *Sida cuneifolia* in the field layer. Other plant species that had less abundant field layer composition included *Hyparrhenia hirta*, *Sesbania sesban*, *Setaria pumilis*, *Sida acuta*, S. *massaica*, and *Solanum nigrum*.

Community type IV - *Euphorbia candelabrum- Euphorbia buseii* community

Both *Euphorbia candelabrum* and *Euphorbia buseii* constituted the dominant tree layer. Other important but less abundant associated field layer species were *Euphorbia tirucalii*, *Ipomea cairica*, *Euclea divinorum* and *Maytenus senegalensis*. This plant community occured in rocky habitats with high sand content in the soil.

Community type V - *Acacia brevispica-Acacia drepanolobium* community

This plant community was mainly dominated by *Acacia* brevispica and *Acacia drepanolobium* in the tree layer. *Acacia gerrardii*, *Acacia seyal* and *Tarchonanthus camphoratus* occured as shrubs. This plant community is highly influenced by altitude. It was found to dominate in areas of higher altitude far away from the lake.

Plant Species Richness and Diversity

It has been argued that species diversity varies from one place to onother due to spatial and temporal heterogeneity of environmental parameters (Whittaker, 1975). The patterns of species diversity in the present study showed that plant community types near the lake have diverse floristic composition compared to those far away from the lake. The diversity of vegetation composition together with species richness decreases with distance away from the lake. This can be associated with reason that most favourable growth conditions for plants have been observed in areas near the lake.

Plant species diversity and richness were found to decrease with increase in altitude. The sample plots from areas far away from the lake were mostly dominated by grasses and herbs except sample plots that were sampled in Eburu forest that had diverse floristic composition comprising of herbs, shrubs, trees and grasses. Human disturbances in form of farming, vegetation clearing, cattle grazing and fire were observed in higher regions than in lowlands. At high rate of disturbance, the pool of adapted species is small thus the species richness and diversity is low (Crawley, 1997 ; White, 1983). The major activities included farming, grazing of livestock, charcoal burning, logging and bush clearing to favor growth of grasses for livestock. The disturbance of natural vegetation by human has been reported to have caused changes in biodiversity of arid and semi arid lands (Crawley, 1997).

The vegetation of the study area comprised of diverse assemblages of different plant growth forms and physiologies which form distinct guilds with respect to water use, because of correlation among morphological, phenological and physiological traits.

Correlation Between Plant Species and Environmental Variables

According to Gauch & Whittaker (1975), Whittaker (1975), Heywood (1995) and Myers (1979), vegetation of any geographical region is as a result of the various environmental factors operating together as a complex unit and often affecting partly one onother; both the physical environment and the vegetation being the cause and partly the effect. Therefore, owing to the spatial variation of the environmental factors and

due to the differences in the combined effects of the several site factors in one place compared with another, the resulting vegetation exhibits corresponding differences. Consequently, well-defined vegetation can be recorganised at different places having different ecological characteristics.

Soil as one of the most important environmental factors and vegetation have a two way relationship. The fact that the vegetation of a given area plays an important role in the development and nature of soil of that area is quite evident. Disregarding the role that the micro-flora plays in the development and maintanance of the soil, it is the higher plants that produce organic matter from inorganic materials of the soil. This means that the higher plants play a very important role in increasing the energy fixing capacity of the soil by adding the decaying organic matter. Higher plants through their long roots, penetrate deep into lower layers of the soil, thus increasing the depth range of the cyclic process. This involves soluble nutrient elements leached downwards and are therefore returned to the surfaces layers of the soil by transport through plants.

According to Thompson & Troech (1978), the soil pH influences the rate of plant nutrient released by weathering, the solubility of all materials in the soil and the amount of nutrients ions stored on the exchangeable sites of the soil. For instance, leaching processes are accelerated under acid soil conditions because more cations are released by acidic soils formed through weathering and fewer ones are held by cation exchange. The results obtained in this study shows that pH and altitude had much influence on availability of different soil nutrients in different sample plots.

Altitude is an important environmental factor which by affecting temperature, moisture, radiation, atmospheric pressure and availability of different soil nutrients influences the growth, development and distribution of different plant species. The effects of altitude in this study was found to affect species diversity, richness and distribution. This is supported by the fact that around lake Naivasha the woodlands, wooded grasslands and shrubland dominated areas of lower altitude while grasses and herbs dominated the regions away from the lake. Woodlands and shrublands were found to have high species richness, diversity and evenness compared to grasslands. It appears therefore that trees and shrubs increased towards lower elevation while herbaceous plants and grasses increased towards higher elevation. Elevated areas are subjected to nutrient removal through runoff (Brady, 1990; Gapta, 1999) and this may have an effect on plant species diversity.

The data collected in the current study show that the amount of organic matter increased with decrease in altitude. This increase of organic matter in lowland could be attributed to decreased microbial activities, resulting into accumulation of plant dead materials (Alan, 1993). Clay soil and low pH were found to be the cause of acidic conditions in areas near the lake. The fact that most of areas in lowland were protected areas under the management of Kenya Wildlife Service (KWS) and Lake Naivasha Riparian Association (LNRA), fires were not a common phenomenon. Lack of frequent fires and poor decomposition of dead plant materials were responsible for accumulation of organic matter in woodlands found near the lake.

Exchangeable cations in the soil replaced from the colloidal complex or which have been dissolved by percolated acids of organic and inorganic compound also influences plant species composition, richness and distribution (Alan, 1993). They are removed from the soil through the water drainage.This is a

normal process in areas with steep slopes, high rainfall and high permeability. This encourages the development of acidity in an indirect way by removing those exchangeable bases which might compete with acidic cations. According to Adams (1986) soil having low pH values are characterized by relatively high concentration of acidic cations and low exchageable bases such as Ca^{++}, Mg^{++}, Na^+ and K^+.

The chemical analysis of exchangeable cations such as magnesium, calcium, pottasium and sodium showed that the study area is rich in basic exchangeable cations, of which calcium and magnesium were the most prevalent. The parent materials and volcanic activities within the Rift Valley may be the result of the relative abundance of the basic exchangeable cations in the soil. Gaudet (1979), Harper (1990) and Harper *et al.* (1990) have described the soil of the areas around Lake Naivasha to be relatively young, being developed on volcanic and pyroclastic rocks and rich in plant available nutrients.

Soil texture by influencing soil-water relationship, aeration and penetrability through its relationship with interparticle pore spaces, is an important environmental factor that determines the concentration of the soil mineral nutrients. The results of the textural analysis of the soil of the study area in the current study, revealed that clay soil prevail in the lower altitude followed by silt soil while sandy soils were mostly concentrated in areas far away from the lake. The relation to vegetetion types of physical properties of soils is partly due to unequal distribution of major rock types within the study area (Brady,1990 ; Alan, 1993). The different soil types favors different plant species. For instance, grasses such as *Eragrostis superba, Digitaria scalarum, Cynodon dactylon, Setaria pumila, Sida acuta, Themeda triandra, and Chloris gayana* together with shrubs such as *Tarchonanthus camphoratus* were found in soils with high sand content. On the other hand *Acacia xanthophloea, Achyranthes aspera* and *Pennisetum clandistenum* dominated the lowland areas that were found to have soils with high clay and water content.

Generally, the texture of the soils found in the study area ranged from clay, clay loam, silty loam, and sandy soil with increasing altitude respectively. The dominance of clay soil in the lower altitude reflects the effect of chemical weathering. Chemical weathering is more rapid in areas of high temperatures and moisture (Juo, 1978; Moore & Chapman, 1986; Alan, 1993). Clay fraction is a main source of many plant nutrients and cation exchange capacity (Adams, 1984 ; Brady, 1990).

Soil with high content of coarse sand retain only small amount of water and the good aeration results to rapid oxidation of added organic to carbon dioxide thus the content of organic matter is therefore low and nutrients such as nitrogen are released to the soil. At low pH the activity of many soil micro-organisms are reduced resulting in accumulation of organic matter and reduced mineralization and a lower availability of nitrogen and phosphorus .Soil organic matter supplies nutrients to the soil.

The interaction of the environmental factors show that with increasing altitude, organic matter, clay content, electrical conductivity, exchangeable basic cations decreases while pH and sand content increases. Consequently, the distribution of plant community types and their differences in floristic composition are attributed to the variation in altitude, upon its effect on the climate, physical and chemical properties of soil and availability of different soil nutrients.

Vegetation distribution of the world depend on several factors and all the environmental factors do not have equal or the same degree of influence on the distribution of a particular plant species or a community type (Alan, 1993). In addition to environmental factors, plant association analysis are useful technique to know the dominant governing factor in influencing the distribution and composition of plant communities found in an area ((Brady, 1990 ; Alan, 1993).

Soil fertility is related to soil parent materials, litter type and the presence of basic microbial species richness (Alan, 1993). Therefore, within an ecosystem, species composition certainly matters, and changes in species diversity can therefore lead to changes in soil fertility. Substantial alterations in soil fertility can be driven by changes in plant species composition both within and among ecosystems.

Conclusions and recommedations

The vegetation types and plant community types around Lake Naivasha were described and was found to be rich in plant species. The major environmental and edaphic factors that influenced patterns of plant species diversity in the study area are electrical conductivity, pH, altitude, sand, pottasium, cation exchange capacity, phosphorus and sodium. Herbivory and trampling by both cattle and wild animals was very common mostly in grassland vegetation types and near the lake and had effect on plant species composition and distribution patterns.

The general pattern of plant species distribution around Lake Naivasha is is mostly associated with edaphic factors. Areas with high ground water table are dominated by *Acacia xanthophloea* woodland and wooded grassland dominated by *Pennisetum clandestinum*. The areas had soils with high clay content, high organic matter, low pH and availability of soil nutrients such as calcium, magnesium, pottasium and phosphorus.

Lake Naivasha and its biological diversity is very important to the society at large and therefore need to be conserved. The area should be considered as gene reserve and natural regeneration area for several economically important plant species e.g *Acacia xanthophloea* and *Achyranthes aspera* are of medicinal value.

There is a need for more scientific researches to be conducted in this area. The vegetation around Lake Naivasha is in danger of over exploitation by man and more so due to land degradation. The effect of these activities on particular plants species need to be studied as some plant species are more sensitive to disturbances than others. Understanding the functional role of biological diversity is important scientifically and from a managerial and policy perspectives.

Due to high rate of human population growth emphasis should be given to better management of available biological resources. Atttempts must also be made to rehabilitate the degraded land inorder to reduce pressure on remaining natural habitats. Therefore, sound management of biological as well as non- biological resources is essential for the overall preservation of biological diversity.

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