# SOIL FACTORS AFFECTING THE INVASIVE GROWTH OF *PTERIDIUM AQUILINIUM* (L). KUHN IN GRASSLANDS OF KUDREMUKH NATIONAL PARK

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***Abstract*– Kudremukh National Park is one of the most valuable and diverse forest wealth in India. It is one of the 24 bio-diversity hot spots in the world. Kudremukh forest area is currently facing colonization by a weedy fern called *Pteridium aquilinum*, which is also known as eagle fern. *Pteridium aquilinum* (L.) Kuhn (bracken) is one of the world's most widely dispersed species, the only terrestrial fern that dominates large tracts of land in tropical regions. In the reserved forests of Kudremukh as well as the regions of Charmadi-ghats the invasive nature of the fern is already proving to be a menace to wild grass grazers and is thus limiting the food for the ungulates which in turn affects the population of tigers in that region. The current study is to understand the invasiveness and gregarious growth in the grasslands of Kudremukh National Park of the Western Ghats region. The soil samples of these regions are collected and tested for various parameters such as bulk density, porosity, water content, pH, sodium, potassium, calcium, organic carbonand their role in growth and colonizing behaviour of the weedy fern *Pteridium aquilinum.* The findings will help the forest department to take control measures to prevent the weed invasion in the grassland.**

***Keywords*: *Kudremukh, Pteridium aquilinum, soil factors.***

## INTRODUCTION

Soil is a mixture of organic matter, minerals, gases, liquids, and numerous organisms that together support life on earth. Soil is an important component of forest and woodland ecosystem as it helps to regulate ecosystem processes, such as, decomposition, nutrient uptake and water availability. *Pteridium aquilinum(L.) Kuhn* (Pteridaceae) is considered to be one of the most successful and widely distributed organisms of the plant kingdom, being present in all continents except Antarctica; the only limitations to its distribution are extreme temperatures and lack of humidity (Zaccone,2014) and can grow at elevations ranging from sea level up to 3000 m (Watrud,2002). Bracken fern is the common name used for all subspecies. Fossil evidence suggests that the plant is at least 55 million years old. It has strong rhizomes as storage organs for carbohydrate accumulation. The plant is widely distributed from the Equator to the northern parts of Europe, in Central Asia, China and Japan, from central South America to subarctic Canada. *P. aquilinum* alters the soil environment in which it grows. It has colonised most grasslands in Shola forests of Western Ghats, causing habitat problems, particularly to the deer population (Hegde, 2013). The production of allelopathic chemicals by bracken could have an important role in allowing bracken to advance by inhibiting the growth of competing vegetation (Whitehead, 1993). The vigour and geographic distribution of bracken has been reported to be affected by soil moisture, by air and soil temperature. Because of its weedy nature, and concern that its geographic distribution could further increase or shift under conditions of elevated $CO_2$ and temperature, bracken has been proposed as an indicator in models of climate change (Watrud, 2002). Bracken is most abundant on well-aerated, loamy soils often on well-drained slopes and soil moisture is another factor which is important in limiting the growth of bracken. The rhizomes are unable to tolerate low oxygen concentrations and bracken is therefore absent from waterlogged areas surviving only in areas which are irregularly wet. In common with many pteridophytes, bracken has a low level of stomatal control and is relatively insensitive to changes in air humidity though it does respond to changes in soil moisture content. The association of bracken with poor soils of low pH (4.6-6.8), low exchangeable calcium and low nutrient status is probably largely due to agricultural economics rather than to the physiology of bracken itself bracken has no specific requirement for acidic soil and has been shown to grow with no significant deleterious effects over a pH range of 3 units. Soil depth is an important factor in the control of bracken biomass which increases together with increasing soil depth. Bracken soils are relatively high in phosphorus and the presence of bracken leachates has been shown to promote the mobilisation of phosphate from inorganic sources. The roots of bracken routinely contain mycorrhiza and experimental plants are known to grow poorly in the absence of mycorrhizal fungi (Whitehead, 1993).

Studies show that, nitrogen additions significantly affected bracken fern and its herbivores at the high pollution site where nitrate decreased in response to nitrogen addition treatments, while biomass and herbivores increased. Observations also suggest that higher rainfall has a positive effect on growth, whereas low temperature has a negative effect (Roos, 2010). Summer drought had the greatest effect, decreasing photosynthesis, growth and reproductive output nearly drought also had an adverse effect on the growth of the fern (Gordon, 1999). Culture work has shown that under conditions of adequate temperature and light, not too acid substrata, spores germinate easily and young sporophytes may readily be obtained (Eric, 1953). Dry spores are very resistant to extreme physical conditions, although the germination of bracken fern spores declines from 95-96% to around 30-35% after three years of storage. The fronds are generally killed by fire, but some rhizomes survive the harsh conditions. The rhizomes are sensitive to elevated temperatures; therefore, during fires the rhizome system is insulated by mineral soil. Fire benefits bracken by removing competition while it sprouts profusely from surviving rhizomes. New sprouts are more vigorous following fire, and bracken fern becomes more fertile, producing far more spores than it does in the shade (Rook, 2010.).

Bracken ferns have been linked with significant health concerns for both grazing domestic animals and human populations. The major bracken carcinogen is a water-soluble nor sesquiterpene glucoside named ptaquiloside (PTA). Domestic animals grazing on lands rich in bracken fern (e.g., horses, pigs, sheep and cattle) can be affected. Besides animals, also humans could be affected by bracken, both directly and indirectly. PTA, as well as other compounds of bracken, may interact with human tissues alone and/or in combination with infectious agents such viruses, particularly papilloma viruses, while epidemiological evidence suggests that PTA causes cancer in humans (Zaccone, 2014). The uses for Bracken include; use as a source of fertility from raw material and ash, weed control for vegetable crops, animal bedding, insect repellent, seed treatment, antifungal agent and biofuel (Donnelly, *et al*., 2002).

The goal of this study was to understand the various soil parameters and the presence of organic content in the habitat which is infested by *P. aquilinum.* Several measures to control the vigorous fern growth and its spreadwere also noted.

## METHOD

The observations are based on survey conducted in different areas of Kudremukh Nation Park, during the year 2016. Field collections of the soil samples were conducted from the selected sites which included fern infested and non-infested areas. The soil samples were collected within located distance of 1km by digging the surface upto 30cm and the photographs of the collection sites were taken. Collected samples were given a specific code depending on their geographical locations. Intensity of light was obtained using Lux Meter while the soil temperature was measured using thermometer.

## SOIL PARAMETERS

**pH:** According to theMethods Manual-Soil Testing in India, soil samples of 10 g was weighed and added to 20 ml 0.01M Calcium chloride solution in a beaker and shaken for 30 min. After 30 minutes the pH was calculated using a calibrated pH meter.

**Soil water content, Soil bulk density, Soil porosity, Volumetric water content and Soil water filled pore space.**

The soil samples collected from Kudremukh sites were analysed as per the guidelines mentioned in Methods Manual- Soil Testing in India. Calculations were done using the formulas given below.

| |
|---|
| 1. Soil Water Content (g/g) = $\frac{\text{Weight of the moist soil - Weight of dry soil}}{\text{Weight of the dry soil}}$ |
| 2. Soil bulk density (g/cm3) = $\frac{\text{Oven dry weight of the soil}}{\text{Volume of the soil}}$ |
| 3. Soil Porosity (%) = 1 – $\frac{\text{Soil bulk density}}{2.65}$ |
| 4. Volumetric water content (g/cm3) = Soil water content × Bulk density |
| 5. Soil Water filled pore space (%) = $\frac{\text{Volumetric water content} \times 100}{\text{Soil porosity}}$ |

**Estimation of Chemical factors**

**Sample preparation:** 5g of soil is mixed with 25ml of ammonium acetate and shaken for 5 minutes then filtered using Whatman No.1 filter paper.

**Organic carbon:** The level of soil organic matter determines the multiplication of microorganisms and makes the system more dynamic (Prescott, 1993). Carbon was estimated calorimetrically by adding 0.1g soil to 1ml 1N Potassium Dichromate and 2ml conc.$H_2SO_4$. The colour obtained was measured at 660nm on colorimeter. Concentration of Organic carbon is derived by plotting standard graph.

**Potassium, sodium and calcium** by ammonium acetate method- Add 25ml of the ammonium acetate extractant to conical flask fixed in a wooden rack containing 5g soil sample. Shake for 5 min and filter. Determine the potassium, sodium and calcium using flame photometer. Concentration of calcium, sodium, potassium, was derived by plotting standard graph.

**Statistical analysis:** All the readings were taken in triplicates. The values plotted in the graph are of mean value with standard deviation. (Methods Manual- Soil Testing in India).

**RESULTS AND DISCUSSIONS**

**SOIL PARAMETERSSOIL pH:** Soil pH influences plant growth improving the soil physical condition and chemical availability. The natural bracken fern biomass has an acidifying effect on soil solution. (Maynard *et al*. 1998). In the current study, the pH of the collected soil samples from the bracken fern area were found to be acidic i.e., below 7, with the exception of sample MM4 which was taken from grassland. Soil samples from the fern area and the grassland area N9, N5, Y06 were highly acidic and the pH values were 3.21, 3.42, and 3.46 respectively. Whereas, highly basic soil sample was found to be MM4 with a value 8.45. As per the study conducted by Sannappa B *et al*. (2013), the normal range of Ph was found to be 4.90 to 7.83 varying from various regions along the Western Ghats.

**SOIL WATER CONTENT (g/g):**

Soil moisture content in soil samples sites GK26, Y10 and S7 were found to be significantly higher and samples from sites MM1 MM3 and L1 have less soil water content as seen in (Fig.02). The study conducted by Rahman N H., suggests that the moisture content was found to be higher in the plantation sites or grasslands than deforested site because of the presence of fully and partially decomposed litter covers over the soil, which help to hold the moisture and also gradually decreased in general with the increase of the depth. The evidence of decreasing moisture content with the increase in soil depth was also revealed by Haque (1997); Chowdhury *et al*., (2007); Shaifullah*et al*., (2008). Jonston and Alongi (1995) also analysed that the soil moisture content was higher due to the presence of vegetation.

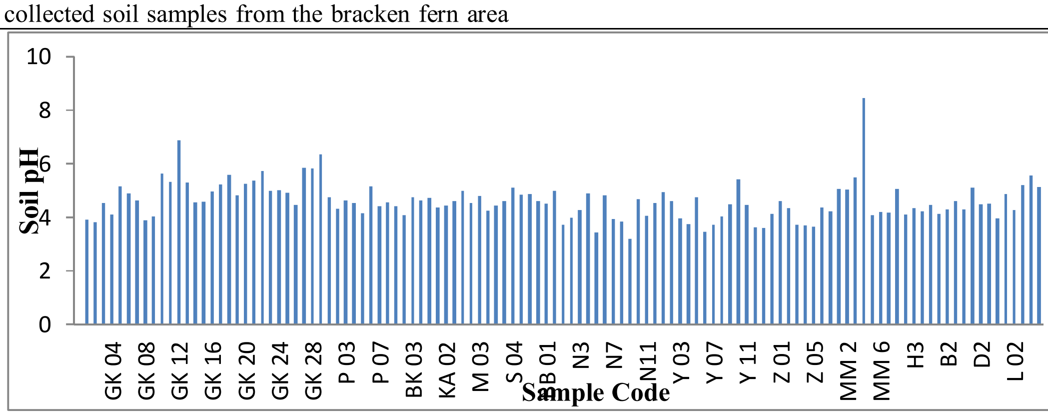


**Fig. 01**: Graph of pH values of the soil samples

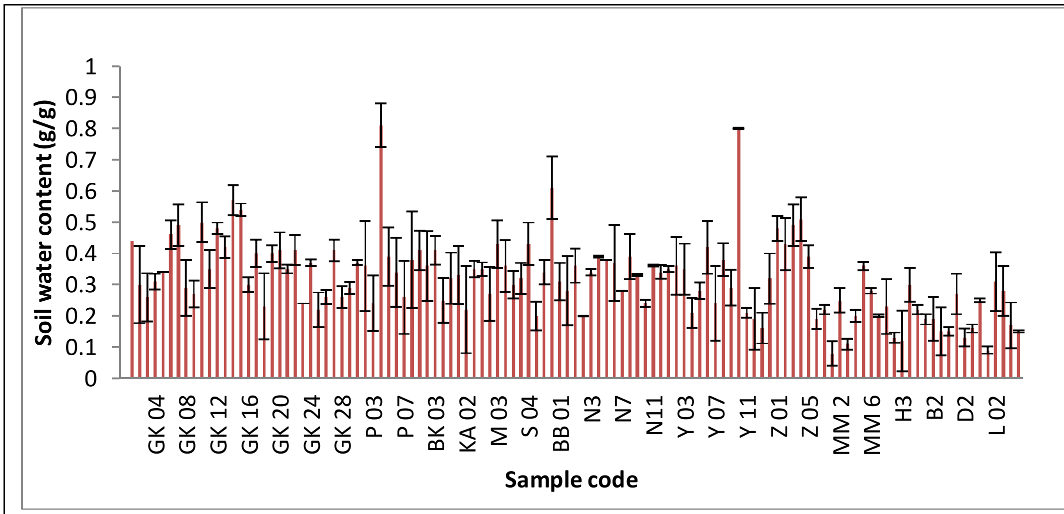


**Fig.02**: Graph of soil water content in the given soil samples

**SOIL BULK DENSITY:**

Lower weight signifies relative porous soil condition and high values indicate greater compactness, lowered field capacity, and lower infiltration rates (Yamamoto, 1963). The soil samples obtained from the sites GK26, MM1 and L5 which was taken from fern invasive region and grassland areas, showed very high bulk density value; greater than 1.6 g/cm$^3$ in contradiction to the study of Yamamoto T. (1963),who also stated that un-grazed grassland soils had the highest average value of bulk density. Compared to this, the soil samples from the sites P4, S7 and Y10 showed the least values as indicated in the (Fig.03). Aforementioned samples were taken from the area with high fern growth. Singh *et al*., (2001) found highest bulk density in both degraded and slightly degraded land compared to undisturbed site. According to the observations made of the sites, the invasive nature of the fern did not depend on the bulk density as it infested both the high and low bulk density soil areas with varying frequency.

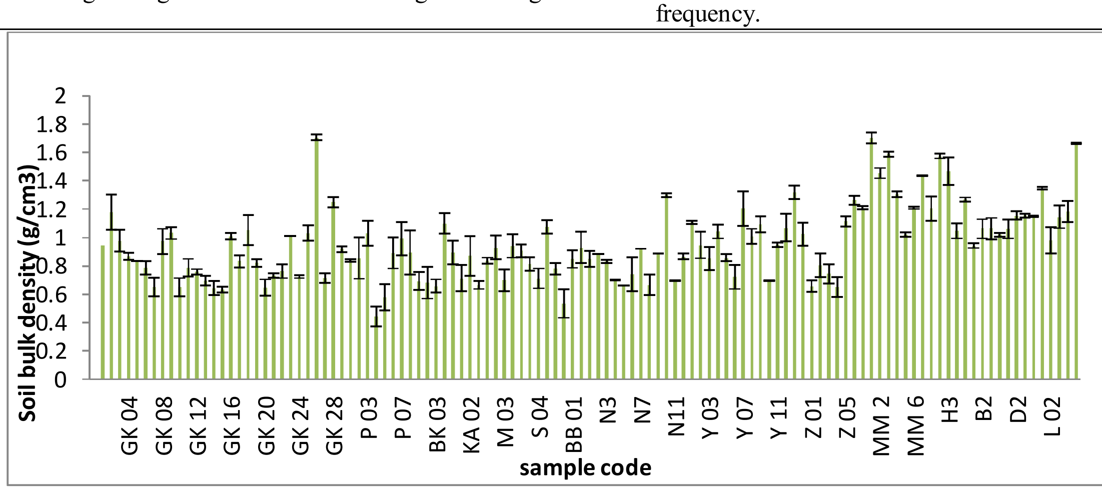


**Fig.03**: Graph of Soil bulk density

**SOIL WATER-FILLED PORE SPACE:**

Yamamoto's (1963) study suggests that the increase in bulk density significantly lowered porosity, but increased the water held at field capacity. Also, the average volume of large pores is highest in the forest soils and lowest in the cultivated and idle grassland soils. This implies that the larger pore size leads to low bulk density of the soil and thus resulting in greater soil porosity. The current values obtained, showed that the volumetric water content and porosity was high in the region of fern growth. The samples GK26, Z5 and MM2 indicated greater values of soil water filled pore space when compared to the grassland region soil samples L01, B02 and B04, as indicated in the Fig.04, 05 and 06.

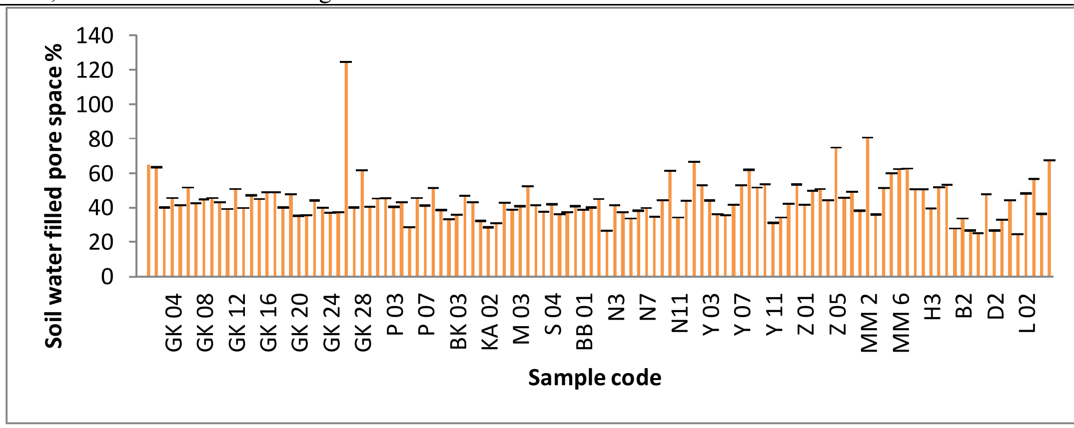


**Fig.04:** Graph of Soil water filled pore space in the given soil samples

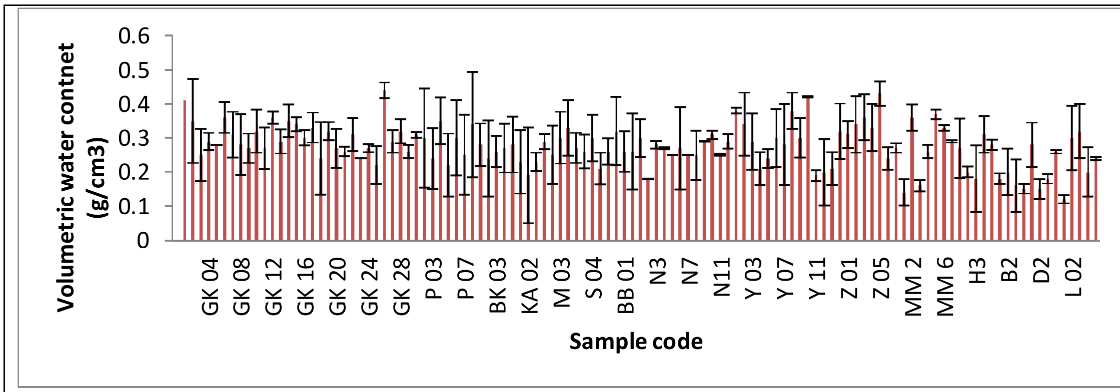


**Fig.05.** Graph of Volumetric water content in the given soil samples

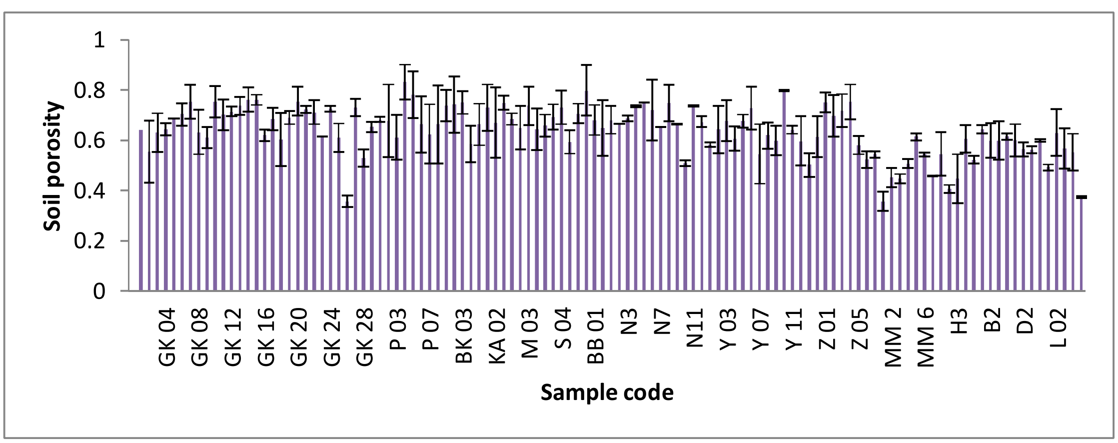


**Fig.06**: Graph of Soil porosity in the given soil samples

## ORGANIC CARBON

Sannappa.*et al*, (2013) stated that the organic carbon content in the soil samples drawn from six different regions of Western Ghats of Karnataka showed significant differences in their values within the range 0.47% to 1.59%. Raina *et al* (2001) also stated that organic carbon content of soils showed positive non-significant relation with pH, the soil organic matter content will be lower in low elevation than high elevation. This is due to the slow decomposition of organic residues. The organic carbon in the present study was found high in samples collected from high fern invasive sites S4, N5 and N11 whereas it was low in grassland areas Y7, Y8 and Y9.

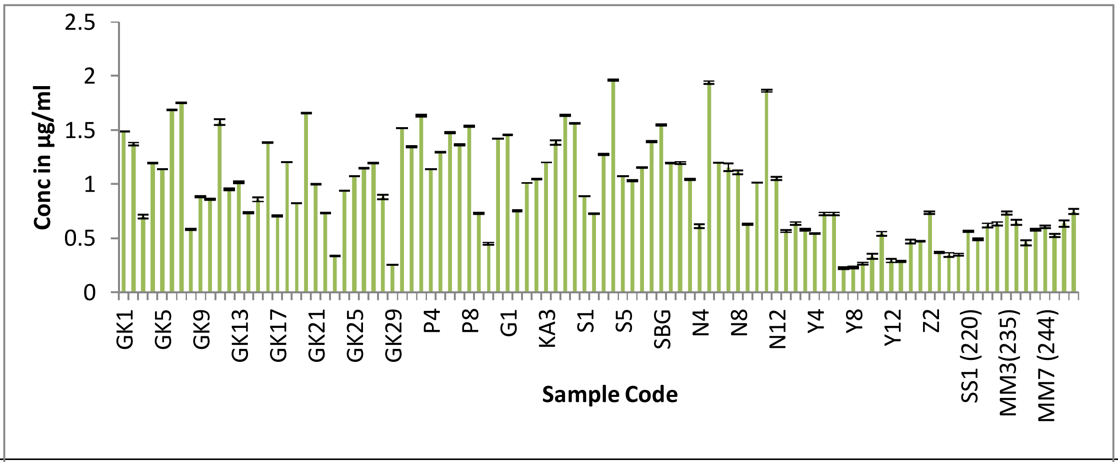


**Fig.07:** Graph of Organic carbon in the soil samples

## SODIUM

Sodium is not a plant nutrient and therefore is not necessary for plant growth. Excessive sodium levels can occur naturally or can result from irrigation with high-sodium water. (Horneck 2011). High level of sodium causes soil to disperse, reducing soil water-holding capacity and aeration (Mc Cauley*et al.*2009). Sodium has still not been shown to be essential for higher plants, of which certain types of C4 plants are an exception (Subbarao*et al*. 2003).As per the current study, the soil samples from the grassland region S3, Y4 and MM2 showed maximum sodium level and the minimum sodium level was found in the fern area N1, S4 and GK14.

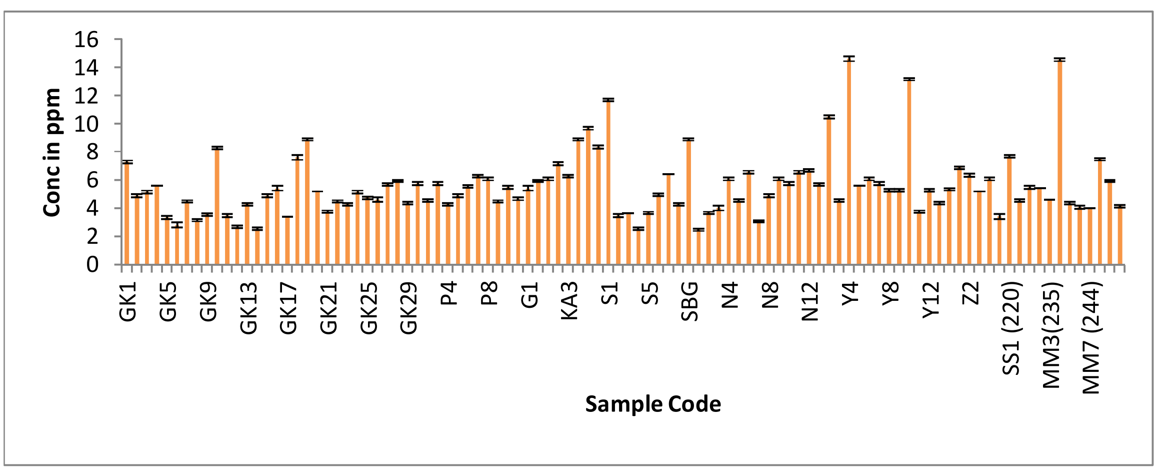


**Fig.08:** Graph of Sodium content in the given soil samples

**POTASSIUM**

Excessive soil potassium levels can result in elevated K levels in grass forage crops, which may be detrimental to animal health. Conversely, very low soil test K levels can reduce plant growth (Horneck, 2011). In the study, conducted by Sannappa*et al. (2013*,) potassium content was found to be in the range of 90.00 kg/ha to 717.0kg/ha in different sites along the Western Ghats region. The average value of available potassium content in selected regions was 507.8 kg/ha (Sannappaet al. 2013). The available potassium content is medium to high in most of the soils of Karnataka except in lateritic soils of coastal plain and Western Ghats, whereas, it was shallow in red and low in black soils (Shivaprasad*et al*., 1998). Highest available potassium content was recorded in Kodagu region (538 kg/ha) when compared to other regions of the Western Ghats of Karnataka (Dakshina Kannada, Udupi and Chickmagalur) (Rajkumar. *et al*., 2012). The soil samples collected from Kudremukh region, Y12, S1 and H3 showed high potassium content whereas sitesGK3, GK12 and GK17 which were high fern growing regions, showed the lowest values.

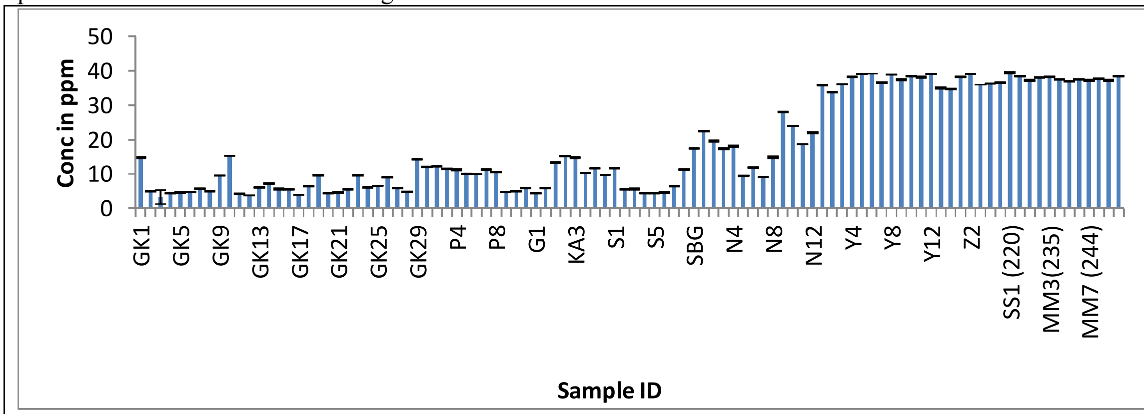


**Fig.09:** Graph of Potassium content in the given soil samples

**CALCIUM**

Calcium is predominant positively charged ion held on soil clay and organic matter particles because it is held more tightly than magnesium, potassium and other exchangeable cations. Leaching of calcium through soils does not normally occur to any appreciable extent because of its relatively strong attraction to the surface of clay particles (Kelling). Calcium deficiencies usually are found only on very acidic soils. They can be corrected by liming with calcium carbonate ($CaCO_3$). Calcium is rarely deficient when soil pH is adequate (Horneck, 2011). The current study of the soil samples from the sites Z10, N6 and H2 showed high levels of calcium content even in acidic soil conditions which contradicts the results of Kelling who stated that soils in low calcium often have low pH. The soil samples had high calcium content and samples GK5, GK6 and GK9 showed minimum calcium content as depicted in (Fig.10).

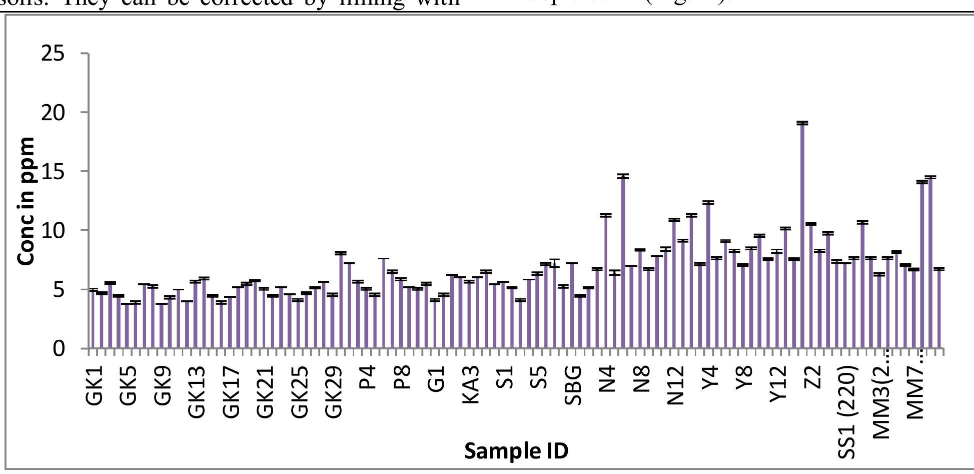


**Fig.10:** Graph of Calcium content in the given soil samples

## CONCLUSION

With reference to the present study, we can conclude that various physical and chemical factors of the soil affect the fern growth in the Kudremukh National Park region. The acidic pH of the soil influences the fern growth. The soil parameters such as soil water content, bulk density, porosity plays a major role in the plant growth. It is stated by Wadsworth (1936) that the increasing rainfall with the vegetation removal (deforestation) decreases soil bulk density. The decreased bulk density in turn increases soil porosity and the soil moisture content, hence favouring the growth of the fern. The natural bracken fern biomass has an acidifying effect on soil solution. Most of the soil samples in this study showed low range of pH depicting the acidic condition of the soil.

The organic carbon in the present study was found high in soil samples collected from fern growing areas. Excessive soil potassium levels can result in elevated K levels in grass forage crops, which may be detrimental to animal health (Horneck 2011). The current study showed high levels of potassium in few soil samples collected from Kudremukh region. Y12, S1 and H3 showed high potassium content whereas GK3, GK12 and GK17 showed the lowest values. Calcium deficiencies usually are found only on very acidic soils. Since the pH of the above soil samples were found to be acidic, more than the average soil samples showed low calcium content.
The presence of stable insect populations feeding on bracken has stimulated interest in the possibility of using biological control agents against bracken according to Whitehead, 1993. The most promising of which are two South African moths *Panotima*sp near *Angularis* and *Conservulacinisigna.* Insect population can be investigated to find out the fern-feeding insects which act as growth control measures (Whitehead J.S. 1993).

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