Impact of Soil and Environmental Conditions on Quality of Coffee

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Abstract- Soils of twelve different locations from where coffee plants procured are collected to investigate their elemental concentrations impact on elemental contents of coffee beans belong to respective locations. Elemental concentrations of soils have been evaluated through the obtained EDXRF spectra. Climatic parameters namely temperature, rainfall and altitude impact on the elemental concentrations of soils as well as coffee beans also been studied. Optimum values of climatic parameters for coffee crop of Ethiopia have been determined. Correlation analysis of elemental concentrations of soils and coffee beans with climatic parameters has been carried out. Based on the results obtained in the above mentioned correlation analysis and experimental measurements of the EDXRF; impact of soils and climatic conditions on elemental contents of coffee beans has been discussed.

Keywords – Soils, elemental concentrations, temperature, rainfall, altitude

I. INTRODUCTION

Coffee is a plant that requires specific environmental conditions for its quality production. It usually grows in tropical region between the latitudes of 25^0 N and 25^0 S [1]. The quality of coffee beans mainly depends on variety of environmental parameters like soil fertility, climatic conditions and physiological parameters of plant growth stages besides processing methods etc [1, 2]. Elemental concentration of plant tissues or seeds influenced by the elemental concentration of the soil at which coffee plants were grown, for example if higher zinc content present in the soil; it enables the plant to have more zinc relative to the zinc deficient soils depending on the species and plant genotype [3]. Fertile soils contribute to coffee bean size, weight and quality of final product [4]. The type of the soil where the plant is grown and the micronutrients of the soil are important parameters that will decide the quality of coffee beans. Field composition and productivity depends on soil properties that relates to biological and geochemical cycles [5], anthropogenic factors like deforestation etc. Soils usually vary in their nutrient concentrations based on the parent material and soil forming factors. Thus determination of elemental concentration present in the soil and coffee beans provides information on soil and plant nutrient inter relation or status. It facilitates to identify the magnitude of existing nutrient limitations [6]. Environmental parameters namely altitude; rainfall and temperature also show impact on quality of coffee beans and thus these are under taken in the present studies.

II. SAMPLES PREPARATION AND EXPERIMENTAL TECHNIQUE

Twelve soil samples were collected from the coffee procured places namely Aleta wendo, Bebeka, Chiro, Yirgachefe, Agaro, Yayu, Harru, Limu, Suppe, Becho, Godere and Mettu. These samples were collected from superficial layer of the soil and at a depth of 20cm. They were mixed together to get homogeneous samples. Polythene bags used for the sample collection were cleaned by soaking and rinsed with distilled water. The soils were dried in oven at 60^0C for 30 hours. The samples were thoroughly ground and homogenized in an agate mortar. A special care was needed to reduce the probability of contamination during preparation of samples.

The experimental measurements were carried out at UGC-DAE-CSR center; Kolkata by employing Energy Dispersive X-ray Fluorescence Spectrometry (EDXRF). The powder specimens of soils exposed to X-rays; further the fluoresced X-rays those emitting from these specimens were collected and displayed with energy dispersive detector systems. The spectra were analyzed by SPECTRO XRF Analyzer Pro operating software; an inbuilt one with the system. The details of samples preparation; establishment of experimental technique through the standard reference materials along with instrumental specifications are give elsewhere [7]. Coffee specimens collected from the above mentioned locations were studied for their elemental concentrations and reported [8].

III. ELEMENTAL ANALYSIS OF SOIL SAMPLES

In the present work 22 elements have been identified and determined their concentrations too. The primary nutrients such as Nitrogen, Phosphorus and Potassium which are essential for plant growth are mainly supplied through fertilizers [9]. Plants need various types of trace elements as secondary nutrients for growth, but their excess accumulation in plants is not good as they become toxic hindering for growth of these plants. Plants primarily acquire their micronutrients from the Rhizosphere and adapt to the soil conditions (i.e. from deficiency to excess), which may be crucial for their optimal growth. The essential elements usually absorbed by the plants through their leaves of roots from the soil [10]. Only a small quantity of these elements is enough for plant growth. [11]. Ultimately, human nutrition also depends on how plants respond to the available trace elements in terms of both nutrients accumulation and yield [12]. The relation between soil and coffee plant for some observed major and minor elements in the present studies has been evaluated. These results might indicate a common intake mechanism, or a common source and a lack of metabolic regulat*ion.*

3.1 Major Elements

In the present study, out of 22 elements detected from soil specimens, only 9 elements are found to present in coffee bean samples. Out of which; based on elemental concentration levels only four elements are considered as major elements and the other five elements categorized as minor elements. The concentration of major and minor elements is shown in the table 1.

3.1.1. Iron

In the present studies, the obtained iron concentration is ranging between 61,312.03 to 1, 50, 040 ppm; thus the average value of this range becomes to 120,863.9 ppm. Lowest value of iron found to occur in Yayu location while highest value is observed at Suppe region. In Coffee beans lower and higher values of Iron are observed at Godere and Bebeka Places [8]. The deficiency of iron happens usually in acid soils. In large portion of the plant species, iron deficiencies happen when the concentration of Fe in the plant leaves is less than 10-80 ppm [13]. The observed Iron concentration of soil in the present investigation is higher than the earlier reported values 23,866 – 32, 262 ppm [14], Fe concentration in the soil of Orissa was observed to be 8.2 – 569.5 ppm [13] while in another study Fe value shown to be 26,000 – 54,000 ppm exhibiting an average value 39,800 ppm [15]. Therefore, the present study area has higher concentration of iron compared to earlier reported values and seems to be not much reflected in the coffee beans.

The ratio of iron present in soil specimens to coffee bean has been evaluated and observed that the iron concentration present in coffee beans do not depend on Fe concentration of soil. It may depend on other parameters like rainfall, temperature and physiological activities of the coffee plant subspecies. The deficiency of Fe in plants may leads to the disability in chlorophyll production. Iron is dispersed from the leaf to the extending areas of meristematic activity.

3.1.2 Calcium

Calcium and Magnesium are usually absorbed by the plants from the soil while sulfur usually provided through fertilizers [16]. Concentration of calcium and magnesium present in the soil specimens are analyzed to understand their role relating to coffee beans. Calcium is the most essential mineral for cell growth in plants and is important for to enhance the absorption of nitrogen. Calcium deficiency shows poorly developed root systems resulting for the relative growth of coffee bean size. The symptoms may slightly vary; the affected plants usually show unusual growth in the terminals and young leaves since Ca is almost immobile in plants.

Table 1 Elemental Concentration of soil samples collected from 12 different study sites
(*Mean* ± *S D*, *n* = 3, ppm dry weight)

Soil Collected place	Fe	Ca	K	Mn	Zn	Sr	Cu	Rb	Se
Aleta wendo	**115624.6 ± 2937.15**	**8598.8 2 ± 280.77**	**10268. 87 ± 307.99**	**5123.59 ± 123.6**	**233.2 3 ± 10.65**	**36.21 ± 1.59**	**45.76 ± 2.05**	**ND**	**2.82 ± 3.68**
Bebeka	**126823 ± 829.93**	**5731.7 5 ± 308.37**	**6028.8 3 ± 217.43**	**8468.45 ± 69.74**	**190.0 2 ± 12.96**	**60.83 ± 5.95**	**47.58 ± 6.49**	**30.74 ± 0.38**	**2.39 ± 3.95**
Chiro	**124104.4 ± 1488.53**	**29383. 6 ± 328.27**	**9341.3 1 ± 163.69**	**2006.4 ± 42.07**	**123.3 1 ± 3.75**	**224.4 ± 8.16**	**126.7 ± 6.46**	**42.94 ± 3.08**	**2.85 ± 2.45**
Yirga chefee	**129695.3 ± 2706.83**	**7532.5 4 ± 362.5**	**10751. 31 ± 67.53**	**3378.38 ± 164.86**	**208.3 3 ± 6.28**	**27.88 ± 4.1**	**47.17 ± 3.94**	**7.92 ± 0.97**	**6.97 ± 6.43**
Agaro	**121019.2 ± 1526.5**	**10406. 3 ± 512.75**	**14073. 87 ± 339.09**	**8109.04 ± 83.58**	**244.2 1 ± 12.37**	**77.09 ± 3.72**	**45.98 ± 8.99**	**ND**	**0.53 ± 0.43**
Harru	**86840.23 ± 2483.89**	**3383.1 0 ± 150.09**	**991.39 ± 262.92**	**1360.89 ± 51.26**	**86.33 ± 14.43**	**ND**	**82.55 ± 6.64**	**63.1 ± 0.78**	**4.93 ± 6.5**
Limu	**123607.4 ± 2940.74**	**8473.3 5 ± 577.44**	**8861.6 2 ± 318.6**	**6143.79 ± 134.64**	**132.5 2 ± 10.49**	**24.52 ± 1.3**	**41.47 ± 4.87**	**ND**	**5.28 ± 9.07**
Godere	**132942.2 ± 4519.05**	**3208.8 9 ± 55.76**	**7028.9 3 ± 430.58**	**2206.84 ± 92.77**	**129.1 6 ± 0.85**	**191.22 ± 10.88**	**84.96 ± 7.13**	**ND**	**9.08 ± 10.45**
Metu	**129278.2 ± 1945.89**	**6024.4 3 ± 180.87**	**10243. 46 ± 134.03**	**5531.45 ± 141.19**	**311.1 7 ± 3.55**	**27.2 ± 3.46**	**70.32 ± 5.15**	**ND**	**1.23 ± 1.41**
Yayu	**150040.6 ± 4013.34**	**17950. 4 ± 662.52**	**7586.6 8 ± 526.64**	**5486.98 ± 192.79**	**196.4 3 ± 9.78**	**81 ± 3.41**	**66.55 ± 1.84**	**27.71 ± 1.14**	**ND**
Suppe	**61312.03 ± 850.02**	**10190. 9 ± 628.75**	**18656 ± 1599.5**	**2065.97 ± 45.22**	**145.6 2 ± 5.09**	**181.77 ± 14.16**	**70.28 ± 4.38**	**ND**	**2.96 ± 5.06**
Becho	**149076.8 ± 1883.03**	**5073.6 ± 15.977**	**3958.0 5 ± 95.49**	**4452.74 ± 51.55**	**133.3 7 ± 11.52**	**9.16 ± 5.014**	**44.86 ± 0.89**	**19.94 ± 3.76**	**0.62 ± 0.59**
Max	**150040.6 ± 4013.34**	**29383. 6 ± 328.27**	**18656 ± 1599.5**	**8468.45 ± 69.74**	**311.1 66**	**224.4 ± 8.16**	**126.7 ± 6.46**	**63.1**	**9.08 ± 10.45**
Min	**61312.03 ± 850.02**	**3208.8 9 ± 55.76**	**991.39 ± 262.92**	**1360.89 ± 51.26**	**86.33 ± 14.43**	**9.16 ± 5.014**	**41.47 ± 4.87**	**7.92 ± 0.97**	**0.53 ± 0.43**
Avg	**120863.9**	**9663.1 41**	**8982.5 28**	**4527.88**	**177.8 09**	**85.5715**	**64.513**	**31.06**	**3.308**

Note: ND=Note Detected

In the present studies Ca concentration of the soil specimens observed to lie in the range 3208.88 - 29383.6 ppm indicating the average value 9663.14 ppm. Higher as well as lower values of calcium belong to Chiro and Godere locations respectively.. Earlier reported calcium range 1800 – 56,000 ppm [16] reflecting its mean value 7500 ppm shows higher values when compared with the presently obtained values. On the other hand higher concentration of calcium is observed in the present studies relative to the earlier reported values 100 – 1,600 ppm [18]. Present results are found to be slightly lower when compared with the values (18,790 – 49,470 ppm) reported by earlier investigators [19]. Present studies show that the intake of calcium by coffee beans; which found to be no much variation [m] doesn't depend on the calcium concentration present in the soils; it may depend on other factors like soil PH, organic, inorganic fertilizers besides environmental conditions

3.1.3. Potassium (K)

Potassium is not usually absorbed from the soil and is usually supplied through the fertilizers along with other primary nutrients [10]. Potassium (K) activates the enzymes those involve in the metabolism; translocation of proteins and carbohydrates that enhances fruit flavor, color and increase oil content [18]. Potassium is present in almost 60 enzymes. It is usually found in actively growing parts and immature seeds of the plants in higher concentrations. Potassium plays an important role in the processes of protein synthesis, water regulation and photosynthesis. Appropriate amount of potassium is needed in plants to improve disease resistance and drought tolerance [13].

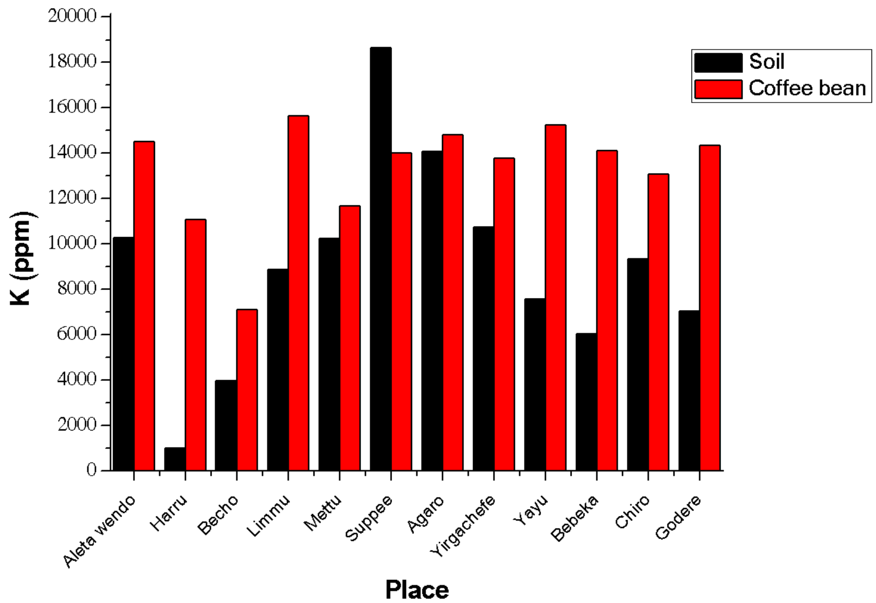

Fig. 1. Potassium (K) Concentration levels in Soil and Coffee beans at various locations

In the present studies, Potassium concentration found to be in the range 991.39 – 18656 ppm compounding to an average value 8982.52 ppm in the soil specimens. The obtained higher and lower values of potassium belong to Suppe and Haru locations respectively. The observed potassium concentration values in the coffee beans are higher than soil specimens as shown in Fig. 1 except Suppee location. Potassium of coffee beans showed positive correlation with Rainfall (r^2 = 0.152) and negative correlations with Altitude (r^2 = -0.087) and Temperature (r^2 = -0.045). Soil specimens' potassium showed negative correlations with Altitude (r^2 = -0.097), Rainfall (r^2 = -0.050) and temperature (r^2 = -0.092). The present evaluation of potassium from soil to plant shows positive correlations (r^2 = 0.147). The intake of potassium in coffee beans depends on the potassium concentration present in the soil specimens besides on other factors and environmental conditions. The obtained values of potassium concentration related to the soil specimens are higher than the earlier reported values of different studied areas such as Baharka district in India has a mean value of K concentration 65 ppm [21] and the soil of Orissa values 21.5 – 80.5 ppm [15]. The reported [16] values of potassium range 4,200 – 15,000 ppm having mean value10, 200 ppm found to show fair agreement with the present results.

3.1.4. Manganese

Manganese plays a key role for activating several enzymes of plants like metabolism by organic acids, phosphorus and nitrogen. Manganese is one of the constituents of certain enzymes those participate in protein synthesis. If the concentration of Mn in a plants tissue exceeds 200 ppm, it becomes toxic. But for coffee specimens; as the Mn required quantity range is only 14.6 – 54.54 ppm; hence it considered to be safe from toxicity [13].

In the present investigation the concentration of manganese of the soil specimens found to be in the range 1360.89 – 8468.45 ppm compounding to an average value 4527.88 ppm. The obtained higher and lower values of manganese belong to Bebeka (54.5 ppm) and Haru (14.5) locations respectively. Except Bebeka location, for all the remaining locations Mn varies in between 14.5 – 28.1 ppm and it seems to be not depended on soil concentration levels. Soil specimens Mn has negative correlations with Altitude (r^2 = -0.078), Rainfall (r^2 = -0.1104) and Temperature (r^2 = -0.092) whereas coffee beans Mn has positive correlations with Altitude (r^2 = 0.337), Temperature (r^2 = 0.189) and negative correlations with Rainfall (r^2 = -0.103). But overall soil to coffee beans Mn concentration ratio showed insignificant positive correlation (r^2 = 0.0793). The obtained concentration of manganese in soil samples of the present study 1360.89 – 8,468.48 ppm with average value 4527.88 ppm is higher than the earlier reported results of Ethiopia 401.8 – 583.7 ppm [14] and Orissa (India) 2.8 – 110.4 ppm [15]. In other words, out of 12 soil samples, 5 soil samples have a fair agreement with reported values 600 – 3200 ppm while the reaming 7 soil samples are higher than reported values [16].

3.2 Micronutrients

The role of micronutrients such as Cu, Cl, Mn, Mo, Zn and B is very important for proper growth and reproduction of plants [23, 24]. In the present study, except Chlorine and Boron, the other five elements are found in soil specimens while molybdenum is not detected in coffee beans. A deficiency of one or more micronutrients might cause to yield crop with poor quality showing hindrance to the growth of coffee plants. All the soils may not contain sufficient amounts of the micronutrients. To get rapid growth and good yield, the knowledge of the nutrients content of the soils is important and the essential micronutrients are to be sprayed [9, 13].

3.2.1. Zinc

In coastal areas, zinc deficiency in plants is caused by the unavailability of Zn in the soil where the plants are growing and its low uptake by the plants. Plants dry tissues zinc concentration ranges from 25 to 150 ppm; if it lies below 20 ppm then it can be considered as Zn deficiency. Zinc concentration of coffee beans belong to present study locations found be in the range 2.6 – 6.05 ppm having an average value 4.3 ppm [8] indicating no much variation. Thus these results indicate deficiency of Zinc in Ethiopian coffee beans. The low uptake of Zn is caused by the presence of excess Phosphorus in the soil [13].

In the present investigation Zinc concentration of the soil specimens found lie in between 86.33 – 311.17 ppm having average value 177.81ppm. The highest value of Zn is observed at Mettu while lowest value observed at Harru locations. Even though large quantities of Zn are observed all over the regions, the Zn quantity of coffee beans seems to be not varied considerably [8]. Correlation analysis of soil and coffee beans found to be negative relation with Altitude, Rainfall and Temperature but from soil to plant it reflected as positive correlation. In the present study Zinc concentration values of soils shows good agreement with the earlier reported data 63.2 – 691.1 ppm having average value 174.2 ppm [22], Ethiopia 137.1 – 213.4 ppm [14] but found to be higher when compared with soil of Orissa 0.55 – 1.85 ppm [15].

3.2.2. Copper

The obtained copper concentration of soils lies between 41.47 – 126.67 ppm with an average value of 64.51ppm. The observed lowest concentration of Cu belongs to Limu location while the highest related to Chiro location. Copper toxicity can be reported in the soils if its concentrations range between 150 to 300ppm [13]. Copper toxicity causes reduced plant growth and vigor, leaf chlorosis reduces branching, thickening and discoloration of roots. The present values indicate that Cu of both soil and coffee beans shows negative correlation with Altitude and Rainfall while positive correlation with Temperature. Significant positive relation is observed between soil and coffee beans indicating relationship between copper contents of soil and coffee beans as shown in Fig. 2. The obtained concentrations of copper present in soil samples show good agreement with the earlier reported data of different countries such as 8.8 – 251.3 with average value 46.3 ppm [22], 3.47 – 202.99 ppm with a mean value of 38.8 ppm [25], in Ethiopia 52.1 – 77.3 ppm [14] but found to be higher when compared with the values related to soil of Orissa 0.38 – 4.00 ppm [15].

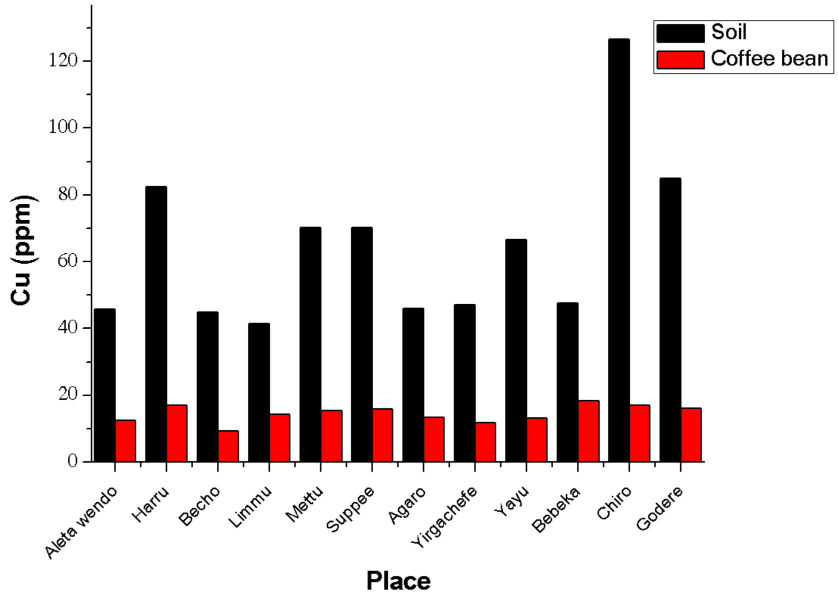

Fig. 2. Copper (Cu) Concentration levels in Soil and Coffee beans at various locations

The obtained copper concentration of soils lies between 41.47 – 126.67 ppm with an average value of 64.51ppm. The observed lowest concentration of Cu belongs to Limu location while the highest related to Chiro location. Copper toxicity can be reported in the soils if its concentrations range between 150 to 300ppm [13]. If the Cu concentration in the plants is beyond the permissible limit, it causes reducing in plant growth and branching. The present values indicate that Cu of both soil and coffee beans shows negative correlation with Altitude and Rainfall while positive correlation with Temperature. Significant positive relation is observed between soil and coffee beans indicating relationship between copper contents of soil and coffee beans as shown in Fig. 2. The obtained concentrations of copper present in soil samples show good agreement with the earlier reported data of different countries such as 8.8 – 251.3 with average value 46.3 ppm [22], 3.47 – 202.99 ppm with a mean value of 38.8 ppm [25], in Ethiopia 52.1 – 77.3 ppm [14] but found to be higher when compared with the values related to soil of Orissa 0.38 – 4.00 ppm [15].

3.2.3. Strontium

Strontium though present in all types of soils it's in take by plants is very low [27]. Apatite rocks and Calcite usually contain Strontium [28]. In the present studies concentration of Strontium of the soil specimens found to lie in the range 9.16 – 224.4 ppm having an average value of 85.57 ppm. The lowest and highest values of Sr are observed at Becho and Chiro locations respectively while it not detected at Haru location. Positive correlation is observed for Sr with Temperature, Soil and Coffee beans. Positive correlation between soil and coffee beans also observed indicating Strontium transmission to plant from soil reflecting role of Strontium present in soil for the obtained Sr concentration of coffee beans. The present results show the lower value of strontium relative to the earlier reported values [29].

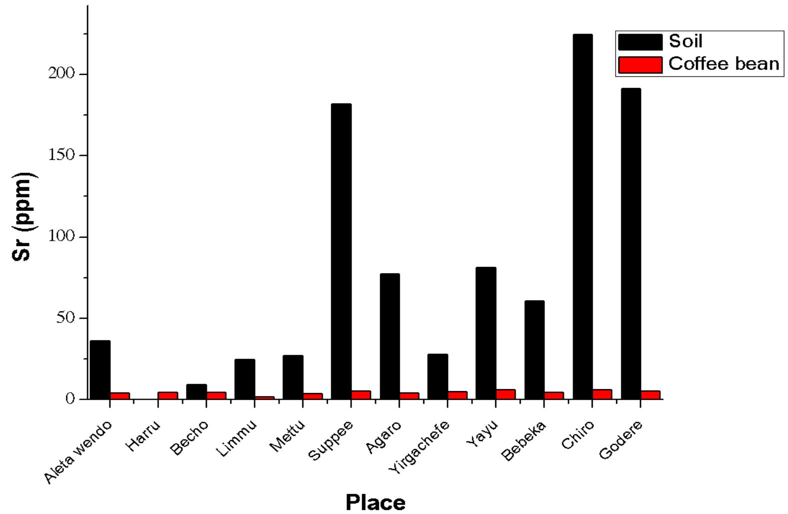

Fig. 4. Rubidium (Rb) Concentration levels in Soil & Coffee beans at various locations

3.2.4. Rubidium

In the present studies, the obtained concentration of Rubidium in soil specimens ranges from 7.92 to 63.1 ppm showing an average value 31.06 ppm. In one of the studies, Rb was present in most of plants in the ranges 20 to 70 ppm, 98 ppm and 130 ppm [31]. Rubidium shows a positive correlation with Temperature for both soil and coffee beans specimens while for all other parameters it showed a negative correlation. The present results indicate that the Rb concentration in coffee beans may depend on content of Rubidium present soil concentration as shown in Fig 4. Regarding concentration of Rubidium in soil specimens, the present values have good agreement with results (5 – 378 ppm) reported by the earlier researchers in subsoil and 2 – 390 ppm in topsoil [32].

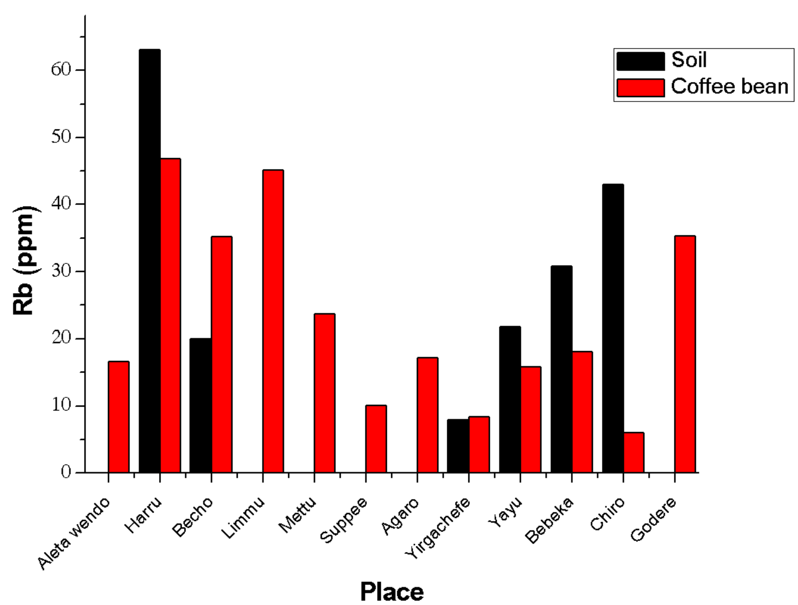

Fig. 4. Rubidium (Rb) Concentration levels in Soil & Coffee beans at various locations

3.2.5. Selenium

Selenium is one of the constituents of many enzymes and present in the form amino acid [33]. Its level in soil varies with geological parent material and climatic conditions [32]. The Se concentration in most of the sandy soils is found to be lesser than that of calcareous and organic soils. Selenium contents present in plants are related with its quantity belong to the respective soils where the concerned plants grow [35]. Some soils show low concentration of selenium (0.03 to 0.08 ppm). If the Se concentration in soils is less than 0.5 ppm of total Se, they are treated as Se deficient [34].

In the present studies the concentration of Selenium of the soil specimens found to be in the range 0.53 – 9.08 ppm having an average value 3.308 ppm. Selenium observed to show a positive correlation with Rainfall while negative correlations with Altitude and Temperature. The obtained positive correlation of Se between soil and coffee beans indicates dependency of Se concentrations present in coffee beans on Se concentrations present in soils. The concentration of Selenium present in soil samples is higher than earlier reported results 0.115 – 0.877 ppm with average value 0.444 ppm [36] and 0.05 – 0.10 ppm [37] but shows a good agreement with other studies of earlier reported results 0.31 – 7.65 ppm [38].

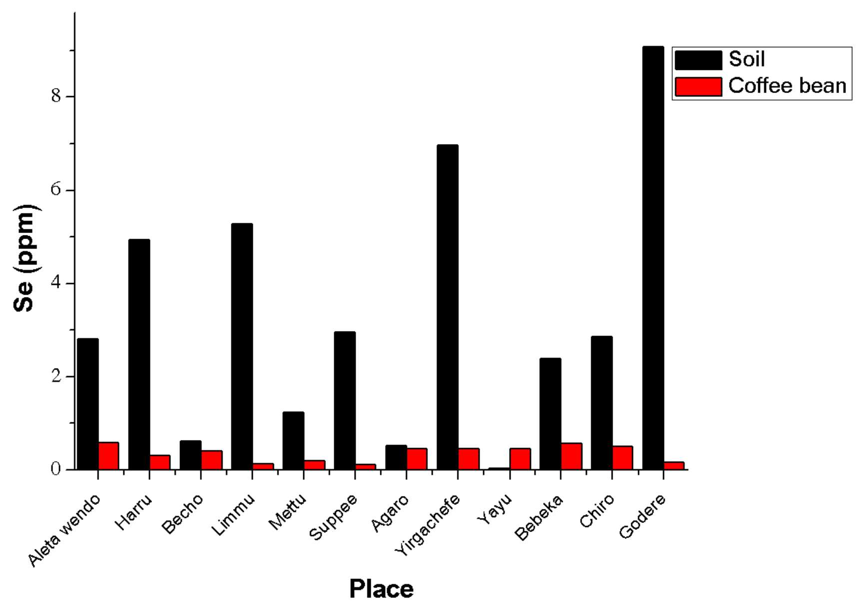

Fig. 5. Selenium (Se) Concentration levels in Soil & Coffee beans at various locations

IV. ENVIRONMENTAL PARAMETERS OF ETHIOPIA AT SITE LOCATIONS

Concentration related to some of the elements those present in coffee beans and soil specimens expected to vary due to environmental parameters like altitude, rainfall and temperature. Coffee grown locations belong to Ethiopia those tolerate much wider ranges of altitude, temperature and rainfall. The rainfall from 500mm to 1,300 mm per year and range of altitude from 1,500m to 1,800m is found to be appropriate for coffee crop production; but required rainfall was found to be above 1,300 mm per year containing an optimum need of rainfall 1,600 – 1,800 mm per year [39, 40]. Average annual temperature required for coffee seems to lie in the range 18 – 24 °C. Rainfall and temperature impact on coffee bean development stages were identified as major contributors to bean physical biochemical compound development as well as tree morphology modifications [41- 43]. Water availability; particularly during the fruit expansion stage often make beans larger than those expand during hot as well as dry weather conditions [42, 44]. Rainfalls are important for the estimation of the duration from flowering to seed maturation; which found to be 8-12 months for most of the species. The temperature of the air is one of the important factors that affects the fruit development rate [42]. Rainfall after a dry spell induces flowering. It is therefore evident that rainfall and temperature affect tree morphology; physical and biochemical composition of beans.

In the present studies tolerable and optimum values of environmental parameters concerned to soil and coffee bean specimens are obtained. The tolerable altitude found to be in between 750-2200 m reflecting optimum values in the range 1500 – 2200 m. The average temperature ranges between 18 – 33 °C exhibiting suitable/optimum values ranging between 18 – 22 °C. Among the 12 studied locations; 8 locations found to show the temperature range almost same showing the range 18 – 21 ^{0}C indicating most favorable conditions for coffee crops. The average annual rain fall found to lie between 1300-2100 mm showing optimum values as 1500-1850 mm per year.

4.1 Impact of environmental parameters on Coffee Beans and Soil Elements

Influence of altitude on elemental concentration varies from one element to other element those present in coffee beans. In order to identify the relationship between altitude and coffee beans elemental concentrations, a correlation analysis has been carried out. Positive correlations are observed between altitude and elements present in coffee beans only for manganese obtaining the value $r^2 = 0.337$. Similarly, correlation analysis has been carried out for altitude and soil elemental concentrations for which positive correlations of Ca (r^2= 0.13) only is obtained. All the values relating to other elements seem to be very low indicating insignificance of altitude on the presence of elements in coffee beans.

In the case of rainfall and elemental concentrations present in coffee beans positive correlations are observed for Ca (r^2= 0.30) and K (r^2= 0.15) while negative correlations obtained for Sr (r^2=-0.1104); Fe (r^2= -0.1103) and Mn (r^2=-0.103). Therefore it can be understood that calcium concentration of coffee beans is influenced by rainfall; which is essential for good health management. On the other hand correlation analysis between rainfalls and soil elements found show negative correlations for the elements Rb (r^2= -0.1108); Mn (r^2= -0.1104) and Zn (r^2= -0.1028) only reflecting decrease of Rb; Mn and Zn concentrations in soils with the increase of rainfall.

To accomplish the relationship between Temperature and Coffee elemental concentrations, correlation analysis has been carried out. Positive correlations are observed between temperatures and few elements of coffee beans namely Sr (r^2= 0.266); Mn (r^2= 0.189); Cu (r^2= 0.147); Se (r^2= 0.129); Fe (r^2= 0.127) and Rb (r^2= 0.126) while negative correlations obtained with the element namely Zn (r^2= -0.109). Similarly positive correlations are observed between temperatures and elements of soil for Ca (r^2= 0.386); Sr (r^2= 0.224); Cu (r^2= 0.159) and Rb (r^2= 0.109). Hence temperature found to influence contents of important elements present in coffee beans and soils. Iron; selenium; manganese and calcium contribute strongly for health maintenance of human beings. To evaluate the relationship between the soil elements and coffee bean elemental concentrations, the correlation analysis has been carried out. Positive correlations are observed between the elements of soil and coffee bean elements such as Sr (r^2= 0.275) < Cu (r^2= 0.232) < K (r^2= 0.147).

V. CONCLUSIONS

1. The suitable climatic conditions for coffee crops in Ethiopia found to be 18 – 22 °C temperature with optimum values of rainfall 1500-1850 mm per year having required range of altitude being 1,500 – 1,800 m .
2. Some elements namely Sr, Mn, Cu, Se, Fe and Rb of coffee beans are found to influenced by temperature while Ca, Sr, Cu and Rb of soils also affected by temperature.
3. Rainfall found to enhance Ca and K concentrations and deteriorate Sr, Fe and Mn contents of coffee beans.
4. Only Mn of coffee beans and Ca of soils are found to get impact by altitude.

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