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Determinations of the Level of Essential and Non-essential Metals in Corm of Enset (*Ensete ventricosum*) and Soil sample

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Abstract: The aim of this study was to investigate the level of essential and non essential metals in corm of Ensete ventricosum and soil samples in West Showa Zone. Ca and Mg were determined complecometric titration method, K and Na were analyzed using FAES, and the other metals with FAAS after appropriate quality control measures were undertaken to verify and maintain the quality of the data generated. The optimized wet digestion method for corm and soil analysis was found effective for all of the minerals and as it was evaluated through the recovery experiment, a good percentage recovery 95% (Fe in corm) to 112% (Pb in soil) was obtained for the minerals identified. The results of this study showed that the average concentrations were ranged in order of decreasing in ($mgkg^{-1}$) 3521.11(K) >3497.85(Mg) >3461.59(Fe) > 3294.93(Ca) >1096.89(Na)> (93.99(Mn) >16.74(Zn) > 3.77(Cu) > 0.26(Cd) for soil sample and Pb was not detected and 16425.13(Ca) >13813.33(K) >1323.55(Mg) > 1131.11(Na) >76.78(Fe) > 16.16(Zn)>2.77(Cu)>1.94(Mn). Cd and Pb were not detected for corm. The concentrations of the metals were also compared with recommended maximum permissible limits and some international reports; and found to be in a good agreement indicating no exposure risk of using the corm of E. ventricosum under the current situation. Statistical test of significance using ANOVA revealed that there were significant differences ($P<0.05$) between the values of metals in the corm and soil samples obtained from all the sampling sites except Zn for corm and Ca in soil.

Keywords: Essential and non -essential metals, corm of E. ventricosum, Soil

1. INTRODUCTION

Root and tuber crops are widely cultivated in southern Ethiopia, which are supporting a considerable portion of the country's population as source of food. Prominent among these are potato (*Solanum tuberosum L.*), sweet potato (*Ipomoea batatas L.*), Enset (*E. ventricosum)*, Godere (*Colacasia esculanta L.*), Yams (*Dioscorea spp.*), Ethiopian dinch (*Coleus parviflorus*), koteharrie (*Diaspora bulbiferous*) and Anchote (*Coccinia abyssinica*). Among these, Enset, Anchote and some yams are endemic to Ethiopia [1]. Enset based farming systems play an important role in food security in Ethiopia[2] and *Ensete ventricosum* is one of the indigenous root crops widely cultivated in the Central, South and South Western parts of Ethiopia, but recurrent droughts have led to the expansion of Enset cultivation to other parts of the country [3-4].

E. ventricosum parts contained high percent of water (85% to 90%), which is beneficial when used as fodder during dry periods. corm *of E. ventricosum* contained 17 of 20 amino acids. Leaves had 13% protein, among the highest available in Ethiopia, 20% crude fibre and 10% sugar. The pseudostem the main food source, was rich in 80% of soluble carbohydrates and 65% of starch, but has low protein content 4% [5].

Eating the right foods is an important part of maintaining a healthy lifestyle. A single day's intake of nutrients may affect the body's organs only slightly but over years and decades the affects of unhealthy diet compounds into disease, shortened lifespan, and a less active lower productive life. The nutrients that we intake today will become part of us tomorrow. The nature and composition of what we eat as determines our future, enset as a food would have its own influential impact on million of peoples in Ethiopia. The corm of enset has rich in essential nutrients and low in non-essential nutrients [6].

The human body requires a number of nutrition to preserve a good health that nutrition accumulated in different parts of plants[7]. Thus plants are intermediate reservoirs through which trace elements from soil and partly from water and air, transfer to man and animal[8]. The content of heavy metals is one of the criteria for the use of plant material as food or traditional medicines. Hence determination of mineral compositions in food and medicinal plant is essential for understanding their nutritive importance and health risk [9].

However, no literature report was found on comparative determination the concentration of essential and non-essential metals in corm of *E. Ventricosum* with its supporting soil samples. Therefore, the aim of this study to compare the level of essential and non-essential metals in corm of *E. Ventricosum* and soil environment from different locations of West Showa Zone, Oromia Regional State, Ethiopia by using flame atomic absorption spectroscopy and flame emission atomic spectroscopy.

2. MATERIALS AND METHODS

2.1. Apparatus and Instruments

Polyethylene plastic bags, Electronic analytical balance with 0.0001 g sensitivity (AA-200DS Deriver Instrument Company, German), A 250 ml round bottomed flasks fitted and reflux condensers, Whatman filter paper (No.42 150 mm, England), Digestive furnace (Model KDN-20C, China), Flame Photometer (ELICO, CL-378, India) and flame atomic absorption spectrophotometer FAAS (Buck Scientific Model 210 VGG, USA).

2.2. **Chemicals and Reagents**

All reagents were analytical reagent grade. The reagents and chemicals used in this study were: HNO_3 (65-68%, Uni-Chem® Chemical Reagent, India), $HClO_4$ (70-72 %, Uni-Chem® Chemical Reagent, India), H_2O_2 (30 %, Uni-Chem®, India, EDTA-Na_2 (98.5-101 %, Unic-Chem®, India) and Stock standard of metals.

2.3. **Sample Collection and Protocol**

The corm of *E. ventricosum* sample was collected in January, 2016 from the three agricultural areas with its supporting soil. Each sample was collected purposely from four different sub-sites (farm lands) to provide replicate samples. From the three agricultural areas corm can be prepared according to the traditional method. The edible designated plant out of the land was cut into three parts for the separation of pseudostem and Corm with knife. The soil sample was collected from the surface 15cm- 25cm depth of the same four sampling areas of Enset by spade. Finally three corm and soil samples one from each stated areas were collected and put in clean cooled polyethylene plastic bags labeled and brought to the Ambo University laboratory.

2.5. Description of the Study Areas

The study areas were conducted in west Showa Zone, Oromia Regional State, Ethiopia. It was found between $8^0 17'$- $9^0 56'$N and$37^0 1'$-$38^0 45'$E.

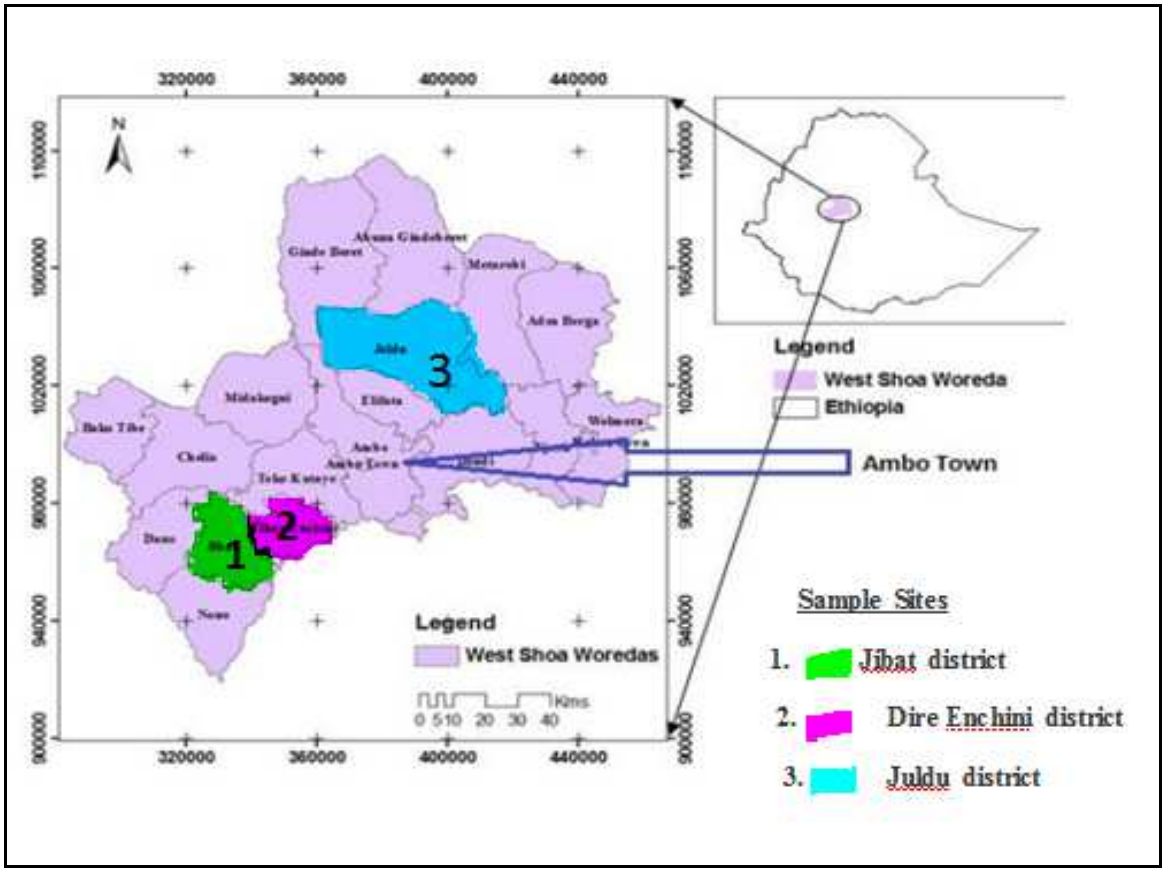

Figure 1: Map of study areas

2.4. Sample Preparation

Corm and soil samples were collected from each sub-sites (kebeles) were air dried for three days to remove moisture and all clods and clumps. The samples were grinded with a mortar and pestle and then sieved through a 2-mm mesh sieve. The four sub-samples were mixed equal proportion together to form a composite sample that represents each sampling areas. The powdered two samples were placed in pre-cleaned screw capped polyethylene container and stored in desiccators containing calcium chloride to keep to constant dry weight till digestion [10].

2.6. Optimization of Digestion procedure for Corm and Soil Samples

0.5 g of air dried and homogenized corm and Soil samples were transferred into a 250 mL round bottomed flask. To this was added 3.5 ml a mixture of HNO_3 (69- 72%) and $HClO_4$ (70%) with a volume ratio of 2:1.5 for corm and 4.5 ml a mixture of HNO_3 (69- 72%), $HClO_4$ (70%) and H_2O_2 (30%) with a volume ratio of 2:1.5:1 for soil. The mixture were digested on a micro Kjeldahl digestion apparatus by setting the temperature 210 ℃ and 230℃ for 1:45hr and 2:30hr respectively. Then, after the digested solution were allowed to cool for 20 min without dismantling the condenser from the flask and for 10 min after removing the condenser. To the cooled solution 25 ml of distilled water was added to dissolve the precipitate formed on cooling and to minimize dissolution of filter paper by the digest residue while filtering with Whatman filter paper. The round bottom flask was rinsed subsequently with 5 ml distilled water until the total volume reached around 45 ml. To this final solution, 1% lanthanum nitrate solution was added and the solution was filled to the mark (50 ml) with distilled water. The digested samples were kept in the refrigerator, until the level of all the metals in the sample solutions were determined by FAAS and FAES.

2.7. Method Validation and Quality Control

2.7.1. Precision and Accuracy

Precision and accuracy of the analytical method was assessed by repeatability and recovery studies of matrix spike (MS) and laboratory control samples (LCS). Recovery study was performed by spiking three replicate of corm and soil samples with a known concentration of metal standard solution. The spiked samples were then subjected to the same digestion procedure like the actual sample. Precision was calculated by

$RSD\% = \frac{S}{\bar{x}} X\ 100$ and accuracy was calculated by this equation [11].

$$\%R = \frac{C_{Spike\ sample} - C_{Unspike\ sample}}{C_{added}}$$

2.7.2. Instrument Detection Limit (IDL)

Instrument detection limits (IDLs) was estimated by taking seven replicate measurements of the calibration blank (Distilled water). The IDL is calculated to the concentration equal to three times the standard deviation of seven replicate measurements of blank [12].

$IDL = 3\ X\ S_b$ Where, S_b is standard deviation of blank (n=7) and IDL is Instrument detection limit

2.7.3. Method Detection Limit (MDL)

Method detection Limit is the minimum concentration of analyze that can be identified measured and reported with 99% confidence that the analyze concentration is greater than zero. MDL was based up on seven replicate measurements of a series of calibration blanks (reagent blank) that are carried through the entire sample preparation scheme [13]. The MDL was calculated by:

$MDL = S\ x\ T - test$ Where, S is standard deviation of the replicated analysis with n-1 degree of freedom, t = 3.71 (T-test value for a 99% of confidence level for six degrees of freedom).

2.8. Method Quantification Limit (MQL)

Method quantification limit was obtained from analysis of seven reagents blanks which were digested in the same digestion procedure as actual samples. The method quantification limit was calculated by multiplying standard deviation of the reagent blank by ten plus the mean of the reagent blank signals [13]. It can be calculated by:

$MQL = \bar{X}_{blank} + 10\ x\ S_{blank}$ Where, $\bar{X}_{blank}$ is the mean of blank, S_{blank} is standard deviation of the blank.

2.8.1. Method Blank

The method blank accounts for contamination that may occur during sample preparation and analysis. These could arise from the reagents, the glassware or the laboratory environment [10]. Sucrose was used as matrix since there was no other plant and clear soil that can serve as the matrix for the corm and soil samples. The blank which was prepared from the sucrose and any reagents used for the digestion was taken through the entire measurement procedure to detect contamination from reagents, sample handling, and the entire measurement process [14].

2.8.2. Matrix Spike

Matrix spike (MS) is portion of a sample spiked with known concentration(s) of target analyte(s). The spiking occurs prior to sample preparation and analysis. The purpose of a matrix spike sample is to determine whether the sample matrix contributes bias to the analytical results[15]. In this study, Matrix spike was prepared for each sample item by spiking aliquots of 0.5 g of each corm and soil samples with 2.5ml standards mixture solution giving concentrations of 1.0 mgL^{-1} for K, Zn, Cd and Pb; 2.0 mgL^{-1} for Na, Cu, Fe and Mn. They were all carried through the same digestion and analysis steps as an unspiked sample. And the mean recovery values of Matrix Spikes were calculated by:

$$\%R = \frac{C_{Spike\ sample} - C_{Unspike\ sample}}{C_{added}}$$

2.9. Transfer Factor of Metals from soil to *E. ventricosum*

Transfer factor is the ratio of the concentration of metals in a plant to the concentration of metals in soil. Transfer factor for each metal was computed based on the method Harrison and Chirgawi (1989) described [16].

$TF = \frac{P_{M\ \mu g g^{-1}}}{S_{m}\mu g g^{-1}}$ Where, p_m is metals concentration in plant and S_m is metals concentration in soil.

2.10. Elemental Analysis of Samples

The digested bulla corm of *E. ventricosum* and soil samples were analyzed in triplicate for Na, K using Flame photometer, Ca and Mg for titration method, Fe, Zn, Co, Cd and Pb using Double Beam Atomic Absorption Spectrometer[17]. Concentrations of the metals in the samples were calculated using:

$Conc.(mgkg^{-1}) = \frac{conc.(mg/L)x\ V}{M}$ Where, V is Final volume (50 ml) solution after digestion, M is initial weight (0.5 g) of sample measured

2.11. Statistical Analysis

Analysis of variance (ANOVA) and F-test at $p<0.05$ are used to examine statically significant differences in the mean concentrations of metals among groups of soil and corm of *E. Ventricosum*. A probability level of $p < 0.05$ is considered statistically significant. All statistical analysis was done by Microsoft Office Excel 2007 was used for data analysis and SPSS Version 16.0 Software Window was used for Analysis of variance (ANOVA) and correlation between metals in corm and soil samples.

3. Result and Discussion

3.1. Method Precision and Accuracy

The mean percent recovery values ranged between 94.85 % Fe in soil to 109 % (Zn in corm), all lied in the acceptable range (80–120 %) for metal analysis [14]. This showed that the analytical method provided results in the required level of accuracy. The RSD values of recovery was ranged between 0.05 % (Mn in corm) to 12.2 % (K in corm), all lied under the required limit ≤15 % [18].

3.2. Instrument Detection, Method Detection and Quantification Limits

The method detection values ranged from 0.08 $mgkg^{-1}$ (Cd in soil) to 2.441 $mgkg^{-1}$(Zn in corm) and the MQL values lied in range from 0.3 $mgkg^{-1}$(Pd in Corm) 4.21 $mgkg^{-1}$(Mn in corm). The results revealed the both MDL and MQL values were greater than the IDL; hence, the results of the analysis could be reliable.

3.3. Calibration

Calibration curves for the various concentrations were ranged between 0.9969 and 0.9999, which were all greater than the required limit (0.995) for trace element analysis. This showed that there was good correlation between concentration and absorbance indicating good calibration of instrument.

Table: 1 Recovery and precision test for the optimized procedure from sample spike (n= 3)

Metals	Sample types	Concentration in Sample (mgL^{-1})	Amount added (mgL^{-1})	Concentration in Spike (mgL^{-1})	Recovery (%)	Precision (% RSD)
K	Corm	143.76±0.76	1.00	141.7±0.87	94.00±11	12.22
	Soil	34.63±0.47	1.00	35.73±0.57	110±11	10.0
Na	Corm	14.53±0.058	2.00	16.50±0.20	98.50±7.1	7.21
	Soil	10.43±0.057	2.00	12.63±0.115	110±2.9	2.64
Fe	Corm	0.62±0.017	2.00	2.512±0.004	94.60±0.65	0.69
	Soil	1.839±0.002	2.00	3.736±0.084	94.85±4.1	4.32
Mn	Corm	0.0113±0.001	2.00	2.173±0.002	108.08±0.05	0.05
	Soil	0.999±0.01	2.00	3.029±0.009	101.50±0.05	0.05
Zn	Corm	0.060±0.002	1.00	1.129±0.003	106.90±0.10	0.05
	Soil	0.171±0.027	1.00	1.179±0.072	100.8±4.50	4.46
Cu	Corm	0.002±0.001	2.00	2.182±0.025	109.00±1.20	1.10
	Soil	0.029±0.005	2.00	2.183±0.048	107.70±2.15	1.99
Cd	Corm	ND	1.00	1.031±0.002	103.1±0.20	0.19
	Soil	0.004±0.001	1.00	1.009±0.005	100.50±0.40	0.04
Pb	Corm	ND	1.00	1.074±0.001	107.40±0.10	0.09
	Soil	0.005±0.0001	1.00	1.123±0.005	112.30±0.5	0.45

* RSD =Relative standard deviation; ND Note Detect.

Table :2 Instrument detection limit (IDL), method detection limit (MDL), method quantization limit (MQL) and correlation Coefficients of calibration curves for determined in corm and soil.

Metals	correlation coefficients of calibration curve	calibration equation	IDL($mgkg^{-1}$)	MDL($mgkg^{-1}$)		MQL ($mgkg^{-1}$)	
				Corm	Soil	Corm	Soil
K	_	_	0.004	0.47	0.478	2.53	2.23
Na	_	_	0.003	0.51	0.465	1.97	1.72
Fe	0.9989	Y= 0.0399x + 0.0033	0.003	1.28	1.187	3.82	3.77
Mn	0.9968	Y = 0.0019x + 0.0076	0.005	2.264	1.21	4.21	3.79
Zn	0.9998	Y = 0.1188x + 0.0043	0.006	0.995	0.944	3.21	3.19
Cu	0.9999	Y = 0.788x + 0.0066	0.010	1.262	1.491	4.14	4.34
Cd	0.9999	Y = 0.1577x + 0.0043	0.005	0.09	0.08	0.70	0.90
Pb	0.9989	Y = 0.1577 + 0.0055	0.006	0.14	0.69	0.39	0.79

3.4. Laboratory Control Samples

The percent recovery values of LCS measurements lied in the range 94.0 % (Na in soil) to 113.6 % (Zn in bulla) and their relative standard deviations 0.09 (Cu in soil) to 11.37 (Cd in soil), and all the values were found under standard control limits 80–120 % for LCS recovery, and ≤15 % for RSD [18]. This showed that the method used for the study has provided the required level of accuracy and precision throughout the analytical process.

3.5. Metal Levels in Corm of E. Ventricosum

The mean concentrations of K was the second most accumulated corm next to calcium.The values of K in corm sample was studied areas ranged from 12050.00 to 15013.33 $mgkg^{-1}$. The highest K was observed in Jibat corm and lowest in jeldu corm, which is below the permissible limit of K in plant dry matter was ranged from 1–5%[18]. While, as have compared the concentration of K in corm in this study less than in corm with the one reported[6], which was ranged from 14100 to 32200 $mgkg^{-1}$.

The analyzed sodium concentration of Corm was ranged from 1023.33 to 1326.67mgkg^{-1}. The lowest Na was observed in Jeldu and highest in Jibat, This concentration was below the WHO recommendation on sodium maximum consumption for adults, which is 2 g sodium/day [20]. The analytical data of Mg in corm of Enset was ranged from 1268.67 to 1370 mgkg^{-1}. The highest Mg was observed in Jibat and lowest in Jeldu, which is below the maximum allowed concentration of Mg 0.1 to 0.4 % in dry matter of plant FAO[18]. The mean concentration of Mg in corm of Enset in this study less than in corm with the one reported [6], which was ranged from 24900 to 26900 mgkg^{-1}.

The average concentration of Calcium in corm was studied areas ranged from 15912.22 to 16875.78mgkg^{-1}. When compared the concentration of Ca, was observed highest in Jibat lowest in Jeldu. This concentration found within the range of the maximum permissible limit of Ca in plant dry matter was ranged from 1–5% [18]. While, as have compared the amount of Ca in corm of enset in this study within the same range with the one reported [6] which, was ranged from 36100 to 39100 mgkg^{-1}.

The concentration of iron was analyzed in corm of Enset sample was ranged from 53.67 to 62.0mgkg^{-1}. The lowest Fe was observed in Jibat Corm whereas highest in Jeldu Corm. This concentration is found within the maximum permissible limit of Iron ranged between 50 to 250mgkg^{-1} in plant dry matter[18]. When, as have compared concentration of Fe in this study almost similar concentration in corm with the one reported [6], which was ranged from 18.2 to 54.4 mgkg-1.

The Concentration of Manganese in Corm of Enset was found between 1.13 to 2.40mgk^{-1}, which was found below the FAO [18]. Maximum permissible limit of 20 to 300mgkg^{-1} When as compared the manganese concentration in Corm from the three sites the lowest Mn concentration was observed in Jeldu corm but, the highest in Dire Enchini Corm and the concentration of Mn in Corm of enset in this study slightly less than with the one reported [6], which was ranged from ND to 5.61µgg^{-1} and 2.0 to 5.0µg-1.

The Concentration of Zn accumulated in corm next to iron among of micro nutrients from the study areas, which was ranged from 15.43 to 17.43mgkg^{-1}. While, the lowest Zn is observed in Jibat and the highest in Dire Enchini, Which was found below the maximum permissible limit of Zn set FAO[18] was ranged from 50 to 250mgkg^{-1} in plant dry matter. The concentration of Zn in this study with the one reported [6], which was ranged from 2 11.9 to 42.3mgkg^{-1}.The mean concentrations of Cadmium and lead were not detected in corm sample ,those were below the acceptable concentration for food stuff which is around 1ppm [21], indicating no exposure risk to Cd and pb. The lowest level of Cd which can cause yield reduction is 5–30ppm [21].

Table: 3 mean concentration of metals (mgkg-1) in Corm sample from Each sites (n=3)

	Corm			Optimum range
Metals	Dire Enchini	Jeldu	Jibat	(mgkg^{-1})
Na	1023.33±25.17	1043.33±15.27	1326.67±4163	NA
K	14376.67±137.48	12050.00±66.58	15013.33±325.17	1-5% [a]
Mg	1332.00±8.76	1268.63±16.43	1370.00±18.00	0.1-0.4% [a]
Ca	15912.67±47.38	16875.73±66.57	16487.33±525.57	0.1-1% [a]
Fe	84.33±1.15	62.00±1.73	84.00±7.51	50-250mgkg^{-1} [a]
Mn	2.40±0.17	1.13±0.11	2.30±0.09	20-300mgkg^{-1} [a]
Zn	17.43±2.41	15.63±0.35	15.43±0.45	300 mgkg^{-1} [a]
Cu	1.87±0.23	2.93±0.11	3.50±0.5	5-20 mgkg^{-1} [a]
Cd	ND	ND	ND	3.0 mgkg^{-1} [b]
Pb	ND	ND	ND	100 mgkg^{-1} [b]

ND is not detected NA is Not Available; [a] source: (FAO. 2008); [b] source: FAO/WHO(Codex Alimentarium commission., (2001)

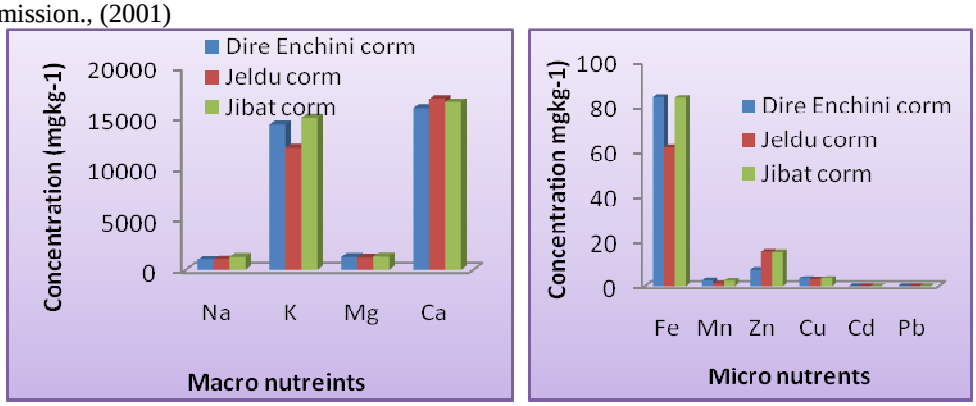

Figure: 2 Concentration of metals in corm of *E. Vectricosum* Sample

3.6. Metal Levels in Soil used for E. Ventricosum cultivated

The analyzed K concentration of the soil sample was ranged from 3403.33 to 3710 mg kg-$^{-1}$. The highest K was observed in Dire Enchini and the lowest in Jeldu, Which is found within the permissible level 1000 to 30000 mgkg^{-1} of K in soil. The values of concentration of K in this study greater than with the one reported [22], which was ranged from 1980 to 6065 mgkg^{-1}.

The analytical data of Ca and Mg in soil sample used for cultivated of Enset were ranged from 2647.33 to 3949.12mgkg^{-1} and 2647.78 to 3934.67mgkg^{-1} respectively. The highest Mg was observed in Jeldu and the lowest in Dire Enchini, Which is found within the permissible level 5000 to 30000 and 1000 to 15000 kgkg^{-1} of Ca and Mg in soil respectively. When, have compared the concentration of Ca and Mg in this study areas soil samples similar with Ca but greater than in case of Mg with the one reported [22], which was ranged from 23866 to 32262 and 1751 to 4288 mgkg^{-1}.

The levels of six trace metals were analyzed in soil samples the results of total concentration of all metals of interest in the soil samples were shown in (Figure 5). The mean concentrations of Fe, Mn, Zn, Cu, Pb and Cd were presented in this study 102.87 to 184.1, 83.1 to 99.87, 11.67 to 20.13, 2.5 to 3.07, 0.49mgkg^{-1} and not detect respectively in the soil samples. The concentrations of all metals in the analyzed soil samples of Enset environment were under the EPA maximum permissible limit of typical concentration in soil dry matter, Fe, Mn, Cu, Zn and Cd are 10–50, 20-30, 2–100, 10–200, 0.1–1 mg kg^{-1} respectively.

3.7. Transfer Factor of Metals from soil to *E. ventricosum*

The transfer factor of metals from soil to *E. ventricosum*, Ca, K, Na, Mg and Cu were more accumulated. When as compared the TF among the different metals, Ca, K, Cu, Na and Zn showed the maximum transfer factor value (Table 2), which ranged from 1.0 (Mg) in Jibat to 6.0(Ca) in Dire Enchini and Mn and Fe were minimum value which, ranging from 0.01 in Jeldu to 0.6 in Jeldu. This is indicated that corm is rich in essential metals. The high level of these metals in *E. ventricosum* might due to direct deposition a foliar absorption more than the translocation upper part of the plant to the root of the plants. This can be attributed to the redistribution of elements within the soil profile.

Table:4 Mean Concentration of Metals (mgkg^{-1}) in Soil Samples from each Sites

	Soil			Max. safe Limit in
Metals	Dire Enchini	Jeldu	Jibat	soil (mgkg
Na	1047.33 ± 15.53	1123.33 ± 20.83	1120.00 ± 51.96	NA
K	3403.33 ± 5.77	3710.00 ± 78.10	3450.00 ± 170	NA
Mg	267.78 ± 10.71	3934.67 ± 5.36	3911.11 ± 28.31	NA
Ca	2647.33 ± 10.08	3949.12 ± 43.74	3788.83 ± 50.08	NA
Fe	183.90 ± 0.17	102.87± 2.11	184.10 ± 0.85	5000 [a]
Mn	99.87 ± 0.06	83.10 ± 1.82	99.00 ± 2.34	200 [a]
Zn	18.43 ± 0.67	11.67 ± 0.25	20.13 ± 1.21	300 [a]
Cu	3.07 ± 0.23	2.73 ± 0.15	2.50 ± 0.10	100 [a]
Cd	0.29 ± 0.01	ND	0.49 ± 0.01	3 [a]
Pb	ND	ND	ND	100 [a]

ND is not detected; [a] source: FAO/WHO(Codex Alimentarium commission., (2001)

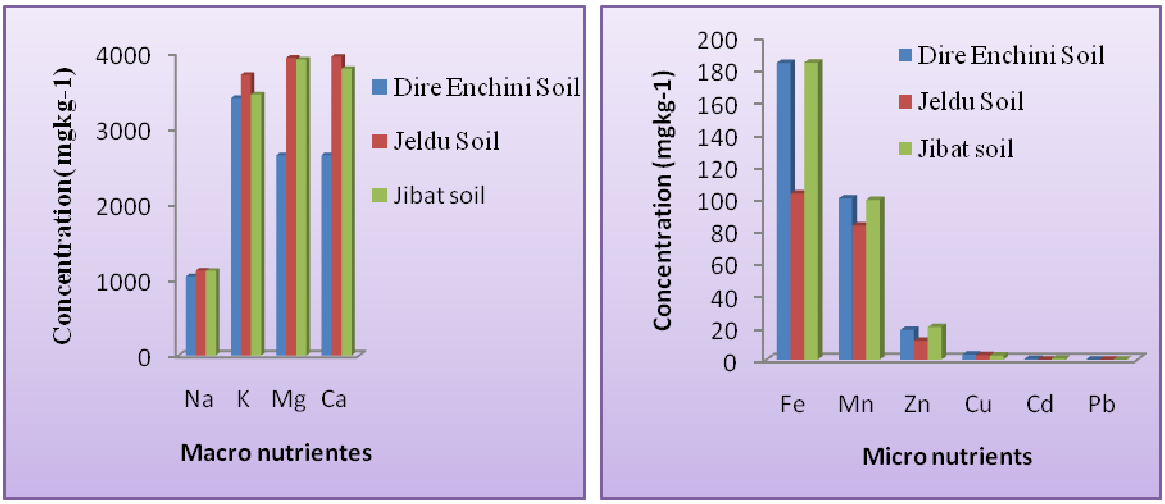

Figure: 3 Concentration of metals in soil Sample

Table:5 Comparison of the metals concentration of unprocessed corm of *E.ventricosum* and Soil samples were determined in this study and other literature.

Metals	Uncrossed corm of *E.ventricosum* in this study	unprocessed corm of *E.ventricosum* [6]	Metals concentration of soil in this study	Metals concentration of soil [23]
Na	1006.7-1336.7	NR	1073-1123	NR
K	3213.3-3463.3	14100-32200	3403-3710	2300.17-2382
Ca	841.3-874.4	36100-39100	2966.67-9633.33	55.2-56.52
Mg	544-665	24900-26900	469.67-543.30	914.83-939.17
Fe	50.67-58.33	18.2-54.4	102.87-184.10	NR
Mn	1.57-4.67	2.0-5.0	83.10-99.87	942-953.5
Zn	6.17-7.40	11.9-42.3	11.67-20.13	55-60.97
Cu	3.47-7.84	1.7-5.2	2.50-3.03	35.46-39.67
Cd	ND	0.6-1.8	NR	NR
Pb	ND	ND-15.3	ND	12.97-15

Table: 6 Transfer (TF) of Metals from Soil to *E. Ventricosum*

Sites	Sample	Metals							
		Na	K	Mg	Ca	Fe	Mn	Zn	Cu
Dire Enchini	corm	0.97	4.22	0.17	6.0	0.46	0.02	0.94	0.8
Jeldu	Corm	0.92	3.24	1.24	4.27	0.60	0.014	1.3	1.07
Jibat	Corm	1.18	4.35	1.0	4.35	0.29	0.02	0.76	1.4

2. Conclusion

The level of essential and non-essential elements in corm of enset and soil sample was determined by flame atomic absorption spectrometry, flame photometry and complexometric titration with EDTA. The distribution of the selected essential and non-essential metals over corm sample of E. Vectricosum and soil were observed, they were found to vary in the order of decreasing Ca > K>Mg>Na > Fe > Zn >Cu> Mn but, Cd and Pb could not be detected from Corm sample and K > Ca >Mg>Na >Fe >Mn >Zn >Cu >Cd >Pb(ND) in soil samples of the three areas. Based on the WHO recommended limit and FAO (2008) the maximum permissible limit for plant, K, Na, Mg, Ca, Fe, Mn, Cu, Zn and Pb, Cd were not found to cause any risk to the people by consuming the E. Vectricosum plants grown in the area where the E. Vectricosum is planted(studied areas). Statistical test of significance using ANOVA revealed that there were significant differences ($P<0.05$) between the values of metals in the corm and soil samples obtained from all the sampling sites except Zn in corm and Ca in soil.

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