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Levels of selected metals in *Ficus sur* Forssk fruit and soil of the plant grown in different parts of Ethiopia

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ABSTRACT: *Ficus sur* Forssk is one of the wild edible plants in Ethiopia. Its fruits are commonly used in different parts of Ethiopia. *Ficus sur* fruits and the soil of plant were collected from three different region of Ethiopia. Levels of selected metals (K, Ca, Mg, Fe, Mn, Zn, Cu, Cd, and Pb) in the fruit and soil were determined by microwave plasma-atomic emission spectroscopy. The validity of the optimized procedure was evaluated by the analysis of spiked samples whose recoveries were in the range of 90.5-108%. The concentration range of metals (mg/kg) in *Ficus sur* fruit samples were K (12372-13687), Ca (3261-5389), Mg (744-785), Fe (418-479), Zn (23.9-25.4), Mn (9.13-18.0), Cu (6.78-7.97), Pb (2.45-6.23) and Cd (0.76-1.42), respectively and in the soil were in the range of 1406-5566 (K), 1248-1453 (Mg), 3140-9403 (Ca), 1186-2421 (Mn), 89763-96704 (Fe), 7.33-13.4 (Pb), 41.4-73.4 (Cu), 123-157 (Zn) and not detected Cd). *Ficus sur* fruit contains all the essential metals to human. However, it also contains toxic metals Cd at trace level and Pb at higher level than World Health Organization permission level.

Keywords/phrases: Accumulation factor, Ethiopia, *Ficussur* Forssk, Fruit, Heavy metals, Wild edible plant

INTRODUCTION

Wild edible plants can be defined as the plants which as whole or their any part (roots, leaves or fruits) are acceptable for eating purpose by urban and rural communities. It is very important to note that plants have many parts, i.e. root, stem, shoot, buds, leaves, fruit and seeds, and if any part (at least one) is comestible, then that plant is considered to be an edible one. A plant considered to be an edible one could also have poisonous, medicinal, bitter, woody, and hairy parts as well. Therefore it is very important to identify which plant is an edible one; in other case it could have disastrous consequences (Shaheen *et al.*, 2017).

Nutritional analysis of some wild food plants demonstrates that in many cases the nutritional quality of wild plants is comparable and in some cases even superior to domesticated varieties (Kebu Balemie and Fassil Kebebew, 2006). *Ficus sur* Forssk is one of the wild edible plants commonly used in different part of Ethiopia. *Ficus* is a genus of about 800 species of woody trees, shrubs, vines, epiphytes and hemi epiphytes in the family *Moraceae*. They are found in the savanna and

rainforest; beside rivers and streams (Odunbaku *et al.*, 2008). Amongst the *Ficus* species are: *Ficus sur*, *Ficus goliath*, *Ficus elastic*, *Ficus exasperata*, *Ficus carica*, *Ficus benjamin*, *Ficus altissima* and *Ficus lingua*, etc.

Ficus sur Forsskis also known as *Ficus capensis* Thunb (*Shola* in Amharic) is a tree of variable height (4-9 m). It has spherical crown, often low-branched leaves and widespread in tropical Africa and South Africa of variable species (Aboaba *et al.*, 2010). *Ficus capensis* also known as the Cape Fig and is a native of tropical Africa and the Cape Islands. The plant is a deciduous tree with spreading roots and branches and broad green leaves. *F. capensis* produces fleshy fruits all year round in a single or branched raceme along the trunk and the main braches (Odeniyi, 2012).

Ficus sur is highly perishable in nature even under refrigerated condition thus nearly all the world production is in the dried form. Basically fresh *Ficus sur* fruit is rich in vitamin-A, calcium, iron and copper. The nutritive index of *Ficus sur* fruit is 11 as compared 9 of apple, 8 of date palms, and 6 of pears. The fruit helps to maintain acid alkali balance for the human body, used as blood purifier and also in the treatment of skin infection

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(Modi *et al.*, 2013). *Ficus sur* produce fruits all year round and have been regarded as an underutilized plant. Its leaves are broad, greenish and are used as vegetable both in soup and yam pottage in various parts of Nigeria (Achi *et al.*, 2017). The picture of *Ficus sur* plant is shown in Figure 1.



Figure 1. *Ficus sur* Forresk plant with edible fruits.

Various parts of the *Ficus sur* plant, such as the bark, leaves, tender shoots, fruits, seeds and latex have been reported to possess medicinal properties. They are used to treat diarrhoea and anaemia as well as sexually transmitted diseases, amongst others. In addition, they can be used as laxatives. *Ficus sur* contains many antioxidants and possess antimicrobial properties. The aqueous leaf extract showed antibacterial activities against *Staphylococcus aureus* and *Escherichia coli* but no activity was observed against *Salmonella typhimurium* (Ramde-Tiendrebeogo *et al.*, 2012).

Furthermore, the latex of *Ficus sur* is used in Congo for the treatment of burns. Tanganyika, a decoction of the bark, is used as a galactagogue in women and cows and to prevent vomiting while in West Africa the plant is used by traditional eye doctors. The leaves chewed and swallowed three times per day for approximately 6 weeks are claimed to act as a remedy for peptic ulcer by people in the middle-belt region of the country personal communication(Kunle *et al.*, 1999). Apart from its above uses, scientific investigations have reported its blood-boosting effect, anti-sickling, antibacterial, anti-abortion, immune-stimulatory, antidiarrhoea, antispasmodic and antiparasitic activities from aqueous extracts of

bark and leaves and pro-fertility in treating azoospermia (Achi *et al.*, 2017).

Plants get nutrient from environmental compartment (soil, water and air). But they are not perfectly selective only to essential nutrients; they may take up heavy metals that are toxic even at low level. Soil is considered a critical environment as it accumulates pollutants like heavy metals that can be dispersed in it, both naturally and by various anthropogenic activities. Metals present in the soil fractions vary in degree of mobility. Their bioavailability is regulated by soil properties (physical, chemical and biological processes) and interactions between them (Hassani *et al.*, 2015). Changes in the chemical properties of the soils greatly affect concentration of free metals and result in changes in their availability for plants. With increasing pH, contents of organic matter and clay; solubility of most metals are decreased due to their increased tendencies for adsorption (Takáč *et al.*, 2009).

Plants readily assimilate elements through the roots. The direct contact between the plant root and soil allows most metals to enter the plant tissue through uptake of water and nutrients by plants, ion exchange at cell wall and other complicated metabolic mechanisms (Smical *et al.*, 2008). Once metals are taken up by roots, they can either be stored by the roots or transported to other parts of the plant. Some plants take up metals and accumulate them in their edible and non-edible parts in quantities high enough to cause risks both to animals and human beings consuming these metal rich plants (Mustapha and Adebayo, 2014).

Heavy metals pose a great health risks to all living organisms upon long term exposures (Getu Alemayehu *et al.*, 2015). Because of their non-biodegradability, long biological half-lives, potential to accumulate in different body parts and their solubility in water; the possibility of causing deleterious health effects is high even at low concentration levels and they have damaging effects to man and animals since there is no good mechanism for their elimination from the body (Mustapha and Adebayo, 2014).

Heavy metals disrupt metabolic functions in two ways: the first is being accumulated in the body, they can disrupt functions in vital organs and glands such as the heart, brain, kidneys, bone, liver, etc. and secondly, they can displace the vital nutritional minerals from their original place, thereby, hindering their biological functions (Takáč

et al., 2009). Because of this, they can pose serious risks to the consumer's in terms of carcinogenesis, mutagenesis and teratogenesis and also lead a number of nervous, cardiovascular, renal, neurological impairment as well as bone diseases and several other health disorders by these two ways (Lokeshappa *et al.*, 2012). Therefore, determination of heavy metals in different food products is necessary to assess the health impacts caused by them.

Assessments of heavy metals contents in different plants, which are used as food source, have been conducted in the world including in Ethiopia. Recently some studies have been done on the mineral contents of fruits of cactus pear (Amare Aregahegn *et al.*, 2013), fennel (Feleke Demissie and Chandravanshi, 2015), banana, grape, guava, mandarin and orange (Shambel Guta Yami *et al.*, 2016), apple (Demisew Jemaneh and Chandravanshi, 2021) and seeds of korarima (Birhanu Mekassa and Chandravanshi, 2015) and fenugreek (Mebrahtu Hagos and Chandravanshi, 2016) cultivated in Ethiopia.

Ficus sur plant might accumulate considerable quantities of essential and non-essential metals in their edible parts depending upon the availability of metals in the soil and climatic conditions. Since the *Ficus sur* fruits are consumed without undergoing any process, these metals are directly available to the consumers. Because of this, the consumers could suffer from metal toxicity and their normal body can be affected. Hence, the determination of the level of the essential and toxic metals in the wild edible plants very important. Despite of this, study on wild edible plant fruits is not getting serious attention in Ethiopia. Therefore, the proposed study was focused on the determination of the concentrations of the accumulated metals in the *Ficus sur* Forssk fruits and the corresponding soil of the plants.

MATERIALS AND METHODS

Equipment

Polyethylene plastic bags were used to pack the harvested *Ficus sur* fruit and soil samples. A drying oven (Digitheat, J.P. Selecta, S.a., Spain) was used to dry *Ficus sur* fruits and soil samples. A

blending device (Moulinex, France) was used to ground and homogenize the dried *Ficus sur* fruit samples. A digital analytical balance (Mettler Toledo, Model AG204, Switzerland) with ± 0.0001 g precision was used to weigh wild *Ficus sur* fruits and soil samples. 250 mL round-bottomed flasks fitted with reflux condensers were used in Kjeldahl (England) apparatus to digest the dried and powdered *Ficus sur* fruits and soil samples. A refrigerator (Hitachi, Tokyo, Japan) was used to keep the digested sample until analysis. Agilent model 4200 (USA) microwave plasma-atomic emission spectroscopy (MP-AES) was used for the determination of the metals (Mg, Mn, Pb, K, Ca, Fe, Zn, Cu, Cd). A ceramic mortar and pestle (USA) was used for grinding and homogenizing the soil samples. Conductivity meter and pH meter (Romania) were used for measuring electrical conductivity and pH of the soil samples.

Reagents and chemicals

All the reagents used were of analytical grade. A (69-72%) HNO_3 (Spectrosol, BDH, England) and 70% HClO_4 , (36-38%) HCl (Aldrich, A.C.S. Reagent, Germany), were used for digestion of *Ficus sur* fruits and soil samples. Strontium nitrate (98%, Aldrich, Milwaukee, USA) was used to avoid refractory interference (for realizing calcium and magnesium from their phosphates). Stock standard solutions containing 1000 mg/L, in 2% HNO_3 , of the metals, K, Ca, Mg, Mn, Fe, Zn, Cu, Pb and Cd (Buck Scientific Puro-Graphictm, USA) were used for the preparation of calibration standards and in the spiking experiments. Distilled water was used throughout the experiment.

Description of sampling sites

Fiche (Oromiya region), Dega Damot (Amahara region) and Chench (South Nations Nationality People Region) were chosen for the collection of *Ficus sur* fruit and its corresponding soil samples. There were two reasons for the selection of these places. First, *Ficus sur* fruits are mostly available in these regions and second, the *Ficus sur* plants are mostly consumed by human beings in these regions. The geographical locations (latitude, longitude, and elevation) of sampling sites are given in Table 1.

Table 1. Geographical location, elevation, and distance from Addis Ababa of sampling sites.

Sampling site	Latitude	Longitude	Elevation (m)	Distance from Addis Ababa (km)
Fiche	9°48'N	38°44'E	2738	126
Dega	11°05'N	37°25'E	1917	552
Damot				
Chencha	6°15'N	37°34'E	2732	478

Collection and preparation of *Ficus sur* fruit samples

The fruits of *Ficus sur* were collected manually using vinyl gloves for protecting hands from getting injury from tiny branches with sharp tips. The bruised portions were removed and the remaining samples packed in the polyethylene bags for transporting to the Analytical Laboratory of Chemistry Department of Addis Ababa University. In the laboratory, collected fruit samples were washed with tap water and then with double distilled water to eliminate adsorbed dust and particulate matters. The fruit samples were then cut and chopped into small pieces using a plastic knife in order to facilitate drying. The samples were then air-dried for five to six days and further dried in a hot air oven at 50-60°C for 24 h (to reduce the drying time), to remove moisture and maintain constant mass. The dried fruit samples were ground into powder using commercial mortar and pestle and then sieved to 0.425 mm mesh size. The sieved samples were finally stored in the polyethylene bags and kept in desiccators until the time of digestion.

Collection and preparation of soil samples

The soil samples were collected from the base of the uprooted plant by auger and properly labeled and packed in polyethylene bags. Each soil sample was air dried at ambient temperature for three days and then, ground into powder using acid washed commercial mortar and pestle and sieved to 0.425 mm mesh. The sieved soil samples were stored in the polyethylene bags and placed in desiccators until the time of digestion.

Soil pH

Soil pH was measured in a suspension (1:2.5, w/v) of the soil and distilled water (Adugna Boke *et al.*, 2015). A 5 g of air-dried soil (< 0.425 mm) was weighed and transferred to a 100 mL beaker to which 12.5 mL distilled water was added. Then,

the mixture was stirred and the pH was measured after allowing the suspension to stand for 10 min at room temperature (Adugna Boke *et al.*, 2015).

Electrical conductivity of soil

The electrical conductivity of the soil samples was measured in suspension (1:2.5 w/v) of the soil and distilled water (Adugna Boke *et al.*, 2015). A 5 g of air-dried soil (< 0.425 mm) was weighed and transferred to a 100 mL beaker to which 25 mL distilled water was added. The mixture was stirred and allowed to stand for 15 min at room temperature and the electrical conductivity was measured.

Soil organic matter

Soil organic matter content was determined using the method of loss on ignition (Adugna Boke *et al.*, 2015). A 5 g of the soil sample of the plant, which dried in an oven at 100°C for 15 min, was accurately weighed into a pre-weighed crucible. Then, the crucible, with soil, was placed in a muffle furnace and heated at 500°C for 3:30 h. The sample was then taken from the furnace and placed in desiccators to cool. Then, the sample was reweighed and the percentage of organic matter content was calculated.

Optimization of digestion procedure for *Ficus sur* fruits

A 0.5 g of powdered and homogenized *Ficus sur* fruit samples was weighed and transferred to 250 mL of a round bottom flask. To this, different volumes of HNO₃ and HClO₄ at specified proportions (v/v) [2 mL (1:1), 3 mL (2:1), 3 mL (1:2), 4 mL (2:2), and 4 mL (3:1)] were added and digested at different temperatures 150, 180, 210, 240, 270 and 300 °C for different duration of time (60, 90, 120, 150, and 180 min). The optimized procedure was determined based on the formation of a clear colorless solution. Thus, 4 mL (3:1) at 270 °C for 3 hours was found to be the optimized condition and used for sample digestion for the analysis. The digested solutions were allowed to cool and 5 mL of distilled water was added to dissolve the precipitate formed on cooling and gently swirled and filtered into 50 mL volumetric flask through Whatman number 42 filter paper. The clear solution was diluted up to 50 mL with distilled water and stored for analysis by

microwave plasma-atomic emission spectroscopy (Adugna Boke *et al.*, 2015).

Optimization of digestion procedure for soil samples

A 0.5 g of crushed, powdered, sieved and homogenized soil samples were weighed and transferred to a 250 mL round bottom flask. To this, different volumes of HCl, HNO₃ and HClO₄, at specified proportions (v/v) was added and digested at different temperatures 150, 180, 210, 240, 270 and 300 °C for different duration of time (60, 90, 120, 150, and 180 min). The optimized procedure was determined based on the usage of lesser reagent volume, shorter digestion time and reasonable mild temperature for obtaining clear and colorless solutions of the resulting digests. The digested solutions were allowed to cool and 5 mL of distilled water was added to dissolve the precipitate formed on cooling and gently swirled and filtered into 50 mL volumetric flask through Whatman number 42 filter paper. The clear solution was diluted up to 50 mL with distilled water and stored for analysis by microwave plasma-atomic emission spectroscopy (Adugna Boke *et al.*, 2015).

Digestion of the fruit and soil samples

For digestion of *Ficus sur* fruits, 0.5 g of powdered and homogenized samples were weighed and transferred to 250 mL of round bottom flask. To this, 4 mL of 3:1 (v/v) of HNO₃ and HClO₄ was added and digested at 270 °C for 3 h. The digested solutions were allowed to cool and 5 mL of distilled water was added to dissolve the precipitate formed on cooling and gently swirled and filtered into 50 mL volumetric flask through Whatman no. 42 filter paper. The clear solution was diluted up to 50 mL with distilled water. The fruit samples were digested in triplicate. Digestion of a reagent blank was also performed in parallel with the samples. All the solutions were stored in tightly capped polyethylene bottles and stored in a refrigerator until analysis. The solutions were used to determine concentrations of K, Ca, Mg, Fe, Mn, Cu, Zn, Pb and Cd by microwave plasma-atomic emission spectroscopy (MP-AES).

Digestion of the soil samples was carried out as follows: 0.5 g of crushed, powdered, sieved and homogenized soil samples were weighed and transferred to a 250 mL round bottom flask. To this, 5 mL of 3:1:1 ratio of HNO₃, HCl and HClO₄

were added. The digested solutions were allowed to cool and 5 mL of distilled water was added to dissolve the precipitate formed on cooling and gently swirled and filtered into 50 mL volumetric flask through Whatman no. 42 filter paper. The clear solution was diluted up to 50 mL with distilled water. The soil samples were digested in triplicate. Digestion of a reagent blank was also performed in parallel with the samples. The solutions were used for the analysis of the soil metal concentrations for, K, Ca, Mg, Fe, Cu, Zn, Mn, Pb, and Cd by microwave plasma-atomic emission spectroscopy (MP-AES).

Calibration of the instrument

A 100 mg/L standard solution was prepared from microwave plasma-atomic emission spectroscopy (MP-AES) standard stock solutions that contained 1000 mg/L. These 100 mg/L standard solutions were diluted with distilled water to obtain four working standards for each metal of interest K, Ca, Mg, Mn, Zn, Fe, Cu, Cd and Pb. The metals in the standards and samples were determined by microwave plasma-atomic emission spectroscopy (MP-AES). Calibration curves were prepared to determine the concentration of metals in the sample solution. The correlation coefficients of the calibration curve for all the metals were $r \geq 0.998$ which indicated good correlation between emission intensity and concentration of the metal.

Recovery test

The efficiency of the optimized procedure was checked by adding the known concentration of each metal to 0.5 g sample of *Ficus sur* fruits. For the recovery test 280, 3.8, 120, 2.00, 6.18, 0.35, 64, 254, and 2.59 µL of 1000 mg/L Mg, Mn, Fe, Cu, Zn, Cd, K, Ca and Pb were spiked to a 0.5 g of *Ficus sur* fruit sample, respectively. These volumes of the standard solutions were added so that the spiked amounts would be within 20-80% of the metals in the original unspiked samples. The spiked samples were treated as that of the respective samples and then reanalyzed. Accepted recoveries ranged from 90% to 110%. The results are given in Table 2. As can be seen from Table 2 acceptable recoveries in the range of 90.5-108 % were obtained for all the determined metals in the *Ficus sur* fruits. Thus, on the average good recoveries were obtained for all elements in the samples. Therefore the optimized procedure has good accuracy.

Table 2. Recovery test results for *Ficus sur* fruit samples.

Metal	Conc. in sample (mg kg ⁻¹)	Amount added (mg kg ⁻¹)	Conc. in the spiked sample(mg kg ⁻¹)	Amount recovered (mg kg ⁻¹)	(%) Recovery
Mg	833	416	1209	376	90.5±4.3
Mn	15.3	7.65	22.4	7.11	93 ±2.2
Fe	479	239	737	258	108 ±6
Cu	7.97	3.99	12.1	4.11	103±1
Zn	24.7	12.4	37.2	12.5	101 ±3
Cd	1.42	0.71	2.11	0.69	97.5±3.2
K	13687	2737	16175	2448	90.9±5.3
Ca	5089	1017	6178	1089	107 ±4
Pb	5.18	2.59	7.85	2.67	103 ±2

Note: % Recovery = [(Concentration in spiked sample –Concentration of standard added)/Concentration of standard added] x 100.

Statistical analysis

All the analysis was done in triplicate and the results are reported as mean of the triplicate measurements. One-way analysis of variance (ANOVA) was used to perform to test whether there are significant differences between means of each *Ficus sur* fruit samples at the stated confidence level. Microsoft office excel 2007 was used to compare the statistical parameters.

RESULTS AND DISCUSSION

Important soil properties

The bioavailability of metals in the plant parts depends on a number of physical and chemical factors in the soils. These include: pH, organic matter content and electrical conductivity(Adugna Boke *et al.*, 2015).The values of soil pH, %OM and EC of the soils for the *Ficussur* plant of the three different places are presented in Table 3.

Table 3. The value (mean ± standard deviation (SD), n = 3) of pH, electrically conductivity (mS/m) and organic matter (%) of the *Ficus sur* plant soil.

Study area	Soil properties		
	pH ± SD	EC ± SD (mSm ⁻¹)	SOM ± SD (%)
Chencha	6.48 ±0.34	71.4 ± 0.40	17.7 ± 0.37
Dega Damot	6.95 ± 0.07	51.1 ± 0.50	11.9 ± 0.96
Fiche	6.92 ± 0.05	18.4 ± 0.97	13.3 ± 0.18

The higher the soil organic matter content, the higher the ability of that soil to retain metals within it (Adugna Boke *et al.*, 2015). The result of the analysis showed that among the three sample sites, the highest % of soil organic matter was obtained in the soil of *Ficus sur* plant from Chencha and the lowest was obtained in the soil of *Ficus sur* plant from Dega Damot. Based on the result, the metals are more retained in the soil of *Ficus sur* plant from Chencha. Therefore, the bioavailability of metals in the soil for the plant species becomes low when the organic content of the soil is high due to the adsorption reaction of metals on it (Adugna Boke *et al.*, 2015). According to this study the bioavailability of metals in soil of

Ficus sur plant is given by the following decreasing order: Dega Damot >Fiche>Chencha.

Most plants grow best in slightly acidic soils (pH 6.0-7.0). In this pH range, nearly all plant nutrients are available in optimal amounts. Soils with a pH below 6.0 are more likely to be deficient in some available nutrients. Ca, Mg, and K are especially deficient in acid soils (Nweke and Nsoanya,2013).Metal solubility tends to increase at lower pH and most of the mobility of metals is reduced with increasing soil pH because of the precipitation as insoluble hydroxides, carbonates, and organic complexes (Nweke and Nsoanya, 2013). Usually, the intensity of root uptake of metal by plants decreases with increasing soil PH. Low soil pH value determines the activity of many

metal ions in the water contained in the pores of the soil, affecting their bioavailability (Adugna Boke *et al.*, 2015). The results showed that the soil pH of *Ficus sur* plant in three study areas is within the range of 6.48 to 6.95, which categorizes the soils under weakly acidic soils. According to (Nweke and Nsoanya, 2013) most plants grow best in this pH range.

Soil electrical conductivity (EC) is a useful indicator in managing agricultural systems. EC directly affects plants growing in the soil or media. EC range of 0-100 mS/m indicates good soil health. Soils that have EC less than 100 (mS/m) is considered to be nonsaline. Soil that has EC of more than 100 mS/m is considered to be saline. Important microbial processes, such as nitrogen cycling, production of nitrous gases and other N oxide gases, respiration, and decomposition of organic matter are affected. Populations of parasitic nematodes and loss of nitrogen can be higher in these soils (Ratul *et al.*, 2018). The result showed that the soil EC of the *Ficus sur* plant in three study areas are within the range of 18.4 to 71.4 mS/m, indicating that soil environment is good for the plant growth (Ratul *et al.*, 2018). EC does not provide a direct measurement of specific ions or salt compounds; it has been correlated to concentrations of nitrate, potassium, sodium, chloride, sulfate, and ammonium ions.

Levels of major and trace metals in *Ficus sur* fruits

The concentration of elements (major and trace) (K, Ca, Mg, Fe, Zn, Mn, Cu, Cd, and Pb) determined in samples is reported as the mean of three measurements with corresponding standard deviation for each metal in Table 4. The results of the analysis showed that the metal contents of *Ficus sur* fruits sample varied for some metals between the areas at which the plant are grown. This variation is probably attributed to the mineral composition of the soil on which the plant has been grown and environmental factors influence the mineral content of the plant. The highest K content was observed for all the study areas; similarly, all the study areas have higher Mg, Ca and Fe contents (Table 4). The highest mean concentration of K was obtained in the Chenchu area followed by Dega Damot and Fiche. The

result further showed that *Ficus sur* fruits in Dega Damot area contain the highest concentration of Ca than the Chenchu and Fiche area. The pattern of concentration of metals in *Ficus sur* fruits from the three areas was decreased as $K > Ca > Mg > Fe > Zn > Mn > Cu$. The mean concentrations of toxic metals (Pb and Cd) in *Ficus sur* fruits sample of selected areas were 2.45; 1.28, 5.18; 1.42, and 6.32; 0.76 mg/kg for Pb and Cd for Chenchu, Dega Damot and Fiche, respectively, having the order of Fiche > Dega Damot > Chenchu for the Pb and Dega Damot > Chenchu > Fiche for the Cd. As can be seen from Table 4, *Ficus sur* fruits are a good source of major and minor metals that are essential to human beings.

Furthermore, *Ficus sur* fruits might be used as a good source of Ca, Mg, K and Fe for good health. The level of Cd and Pb are higher than the WHO permissible level (Codex Alimentarius Commission, 2011) which needs further treatment before consumption. Ca is an essential and the most abundant mineral in human body. It has many benefits for the health of bone and teeth, functioning of the muscles and nerve tissues, communications between the brain and the body, blood circulation and hormonal system. The value of recommended dietary allowance (RDA) for Ca, Mg, K, Mn, Fe, Cu and Zn are reported as 1000, 320-420, 4700, 1.8-2.3, 8-18, 0.9 and 8-11 mg day⁻¹. According to our results, the RDA (mg day⁻¹) value of Ca, Mg, K, Mn, Fe, Cu and Zn are varied between 3261 (Fiche) - 5389 (Dega Damot), 3261 (Chenchu) - 5389 (Dega Damot), 3261 (Fiche) - 5389 (Chenchu), 3261 (Fiche) - 5389 (Chenchu), 3261 (Chenchu) - 5389 (Dega Damot), 3261 (Chenchu) - 5389 (Dega Damot), and 3261 (Chenchu) - 5389 (Fiche), respectively. Therefore, a daily consumption of 100 g of *Ficus sur* fruits provides 32.6% (Fiche) - 53.9% (Dega Damot), 17.7% (Chenchu) - 26.0% (Dega Damot), 26.3% (Fiche) - 29.1% (Chenchu), 39.7% (Fiche) - 100% (Chenchu), 232% (Chenchu) - 599% (Dega Damot), 75.3% (Chenchu) - 88.6% (Dega Damot), and 21.7% (Chenchu) - 31.8% (Fiche), Ca, Mg, K, Mn, Fe, Cu and Zn, respectively.

Table 4. Concentration of metals (mg/kg), (mean $\pm$ SD, n = 3) in *Ficus sur* fruits.

Study areas	Concentration of metals (mg/kg)								
	K	Mg	Ca	Mn	Fe	Cu	Zn	Pb	Cd
Chencha	13687 $\pm$ 20	744 $\pm$ 5	5089 $\pm$ 11	18.0 $\pm$ 0.10	418 $\pm$ 2	6.78 $\pm$ 0.10	23.9 $\pm$ 0.3	2.45 $\pm$ 0.02	1.28 $\pm$ 0.01
Dega Damot	13028 $\pm$ 20	833 $\pm$ 6	5389 $\pm$ 13	15.3 $\pm$ 0.80	479 $\pm$ 2	7.97 $\pm$ 0.10	24.7 $\pm$ 0.3	5.18 $\pm$ 0.05	1.42 $\pm$ 0.01
Fiche	12372 $\pm$ 22	785 $\pm$ 7	3261 $\pm$ 16	9.13 $\pm$ 0.90	435 $\pm$ 2	7.66 $\pm$ 0.10	25.4 $\pm$ 0.2	6.23 $\pm$ 0.03	0.76 $\pm$ 0.02

Levels of major and trace metals in *Ficus sur* plant soil

The levels of metals in the soil of *Ficus sur* plant are given in Table 5. Among the macro elements, Ca content of the soils is higher within a range of 3140-9403 mg/kg followed by K (1406-5566 mg/kg) and Mg (1248-1453 mg/kg) in all study areas for the soil of *Ficus sur* plant. The result further showed, Fe content of the soils is higher

within a range of Fe (89763-96704 mg/kg), followed by Mn (1186-2421 mg/kg), Zn (123-157 mg/kg) and Cu (41.4-73.4 mg/kg). On the other hand, the level of the toxic heavy metal Pb ranges from (7.33 mg/kg) for the soil of Dega Damot up to 13.4 mg/kg for soils of Fiche. The level of Cd in soils of all study area was found to be below the detection limit.

Table 5. Concentration of major and trace metals (mg/kg), (mean $\pm$ SD, n = 3) in the soil of *Ficus sur* plants.

Study areas	Concentration of metals (mg/kg)								
	K	Mg	Ca	Mn	Fe	Cu	Zn	Pb	Cd
Chencha	4806 $\pm$ 6	1248 $\pm$ 6	9403 $\pm$ 10	2421 $\pm$ 10	89763 $\pm$ 12	41.3 $\pm$ 2.0	123 $\pm$ 4	7.40 $\pm$ 1.07	ND
Dega Damot	4935 $\pm$ 9	1310 $\pm$ 6	3140 $\pm$ 11	1186 $\pm$ 10	95859 $\pm$ 15	73.4 $\pm$ 3.1	141 $\pm$ 5	7.33 $\pm$ 0.72	ND
Fiche	5566 $\pm$ 9	1453 $\pm$ 7	6015 $\pm$ 12	2163 $\pm$ 9	96704 $\pm$ 12	45.9 $\pm$ 2.1	151 $\pm$ 3	13.4 $\pm$ 0.3	ND

ND - Not detected

Comparison of metals concentration in range for *Ficus sur* fruits sample and its soil samples from three study area

Distribution of selected metal levels (mg/kg, dry weight) in the fruits of *Ficus sur* plant and its soil is shown in Tables 4 and 5. The results showed that except Cd and K all the metal concentrations in soil of *Ficus sur* are higher than the fruit of *Ficus sur*. This may be the capability of plant species to uptake metals. Once metals are taken up by roots, they can either be stored in the roots or exported to the other part of plants. Efficient transport of metals to other parts of plants is an important aspect of plant metal accumulation. The transport of metals from root to other parts of plants is come out primarily through the xylem. Organic acids and amino acids have frequently been reported to be the potential metal chelators, which most likely facilitate metal translocation through the xylem. Without being chelated by ligands, movement of metal cations from roots to shoot (other parts of plants) is expected to be severely retarded as xylem cell walls have a high cation exchange capability (Adugna Boke *et al.*, 2015).

Accumulation factor of metals from soil to plant

Transmission of metals from soil to plant is studied using an index called accumulation factor (AF). It is calculated as a ratio of the concentration of a specific metal in the plant to the concentration of same metal in the soil, both represented in same units. Higher AF values (≥ 1) indicate higher absorption of metal from the soil by the plant and higher suitability of the plant for phyto-extraction and phytoremediation. On the contrary, lower values indicate the poor response of plants towards metal absorption and the plant can be used for human consumption (Mirecki *et al.*, 2015). The summary of AF values for selected metals in *Ficus sur* plants collected from the study areas are given in Table 6.

Loading and accumulation of metals in the soil depend on different factors such as the chemical form of elements, pH, organic matter content, texture and cation exchange capacity (CEC) of the soil. With increasing pH, organic matter content, CEC, and clay, the percentage, and availability of the metals are reduced. In addition, the existence of carbonate, sulfate and phosphate and sulfide in the soil creates an increase in the metal

precipitation and consequently decrease their availability to the plants (Mirecki *et al.*, 2015).

Metal accumulation factor from soil to plants is a key module of human exposure to metals via the food chain. Accumulation factor of metals is essential to investigate the human health risk. The range of AF values for *Ficus sur* fruits were 2.22 to

2.85, 0.54 to 0.64, 0.54 to 1.72, 0.0042 to 0.01, 0.0045 to 0.005, 0.11 to 0.17, 0.17 to 0.19 and 0.33 to 0.71 for K, Mg, Ca, Mn, Fe, Cu, Zn, and Pb, respectively. The AF value of K for *Ficus sur* fruits in all study areas and Ca from Dega Damot is more than 1. This indicates that the *Ficus sur* fruit is K and Ca metal accumulator.

Table 6. Accumulation factor (AF) values for selected metals in *Ficus sur* plant fruits from the soil.

Study areas	Transfer factor values								
	K	Mg	Ca	Mn	Fe	Cu	Zn	Pb	Cd
Chencha	2.85	0.60	0.54	0.01	0.0046	0.16	0.19	0.33	-
Dega damot	2.64	0.64	1.72	0.01	0.005	0.11	0.18	0.71	-
Fiche	2.22	0.54	0.54	0.0042	0.0045	0.17	0.17	0.47	-

The result in Table 6 showed the accumulation factors for all the metals except K and Ca are less than one for all three areas. This indicates high metal concentration in soil in relation to levels in *Ficus sur* plant fruits which reflects low uptake of metals by *Ficus sur* fruits from the soil, therefore, lower values indicate the poor response of plants towards metal absorption and the plants can be used for human consumption.

Correlation coefficient of metals

Pearson's correlation coefficient was used to investigate correlations between metal concentrations in the *Ficus sur* fruits (Table 7). The high correlation coefficient (near +1 or -1) means a good relationship between two variables, and its concentration around zero means no relationship

between them at a significant level of 0.05% level, it can be strongly correlated, if $r > 0.7$, whereas r values between 0.5 to 0.7 shows moderate correlation between two different parameters (Rakesh Sharma and Raju, 2013). The results of the analysis in Table 8 showed Pearson correlation coefficients between metal concentrations in *Ficus sur* fruit samples. Very strong correlations included K/Ca, K/Mn, K/Zn, K/Zn, K/Cd, Mg/Fe, Mg/Cu, Ca/Mn, Ca/Fe, Ca/Zn, Ca/Zn, Mn/Fe, Mn/Zn, Mn/Pb, Mn/Cd, Fe/Cu, Cu/Zn, Cu/Pb and Zn/Pb. The lowest correlation coefficient at 0.14 with Ca/Cu. This indicates poor relation among metals. The correlation coefficient values for K/Cd and Cu/Mg were the same. Finally, among the following pairs, Mg/Pb, Ca/Pb, Fe/Pb, Zn/Cd, and Pb/Cd medium correlation occurs.

Table 7. Pearson correlation coefficients between metal concentrations in *Ficus sur* fruit samples.

	K	Mg	Ca	Mn	Fe	Cu	Zn	Pb	Cd
K	1.00								
Mg	-0.46	1.00							
Ca	0.79	0.18	1.00						
Mn	-0.92	0.08	-0.97	1.00					
Fe	-0.27	0.98	0.37	-0.12	1.00				
Cu	-0.71	0.95	-0.14	0.39	0.87	1.00			
Zn	-1.00	0.53	-0.74	0.89	0.35	0.77	1.00		
Pb	-0.97	0.67	-0.62	0.80	0.50	0.86	0.99	1.00	
Cd	0.75	0.25	1.00	-0.95	0.44	-0.07	-0.69	-0.56	1.00

Analysis of variance

One-way analysis of variance (ANOVA) was used to perform the statistical analysis with *Ficus sur* fruit as independent and concentration of the metals as a dependent variable to test whether there are significant differences between means of each *Ficus sur* fruit samples at the stated confidence level. The result of the analysis is depicted in Table 8. From the result depicted in Table 8, there is a significant difference between means of *Ficus sur* fruit samples from the three

sites at 95% confidence level for K and Mg and insignificant variation between means of *Ficus sur* fruit samples from the three sites at 95% confidence level for Fe, Mn, Zn, Cu, Mg, Cd and Pb. Variations between the samples in the mean levels of the *Ficus sur* fruits is might be due to the difference in the mineral composition of the soil, climatic conditions, or variations in soil parameters such as the pH, soil organic matter and electrical conductivity.

Table 8. Analysis of variance (ANOVA) within and between samples of *Ficus sur* fruit.

Parameters	Metals compared at 95% confidence level								
	K	Ca	Mg	Fe	Mn	Cu	Zn	Pb	Cd
F _{critical}	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14	5.14
F _{calculated}	154	178	3.23	2.49	2.96	2.90	1.47	1.13	2.11

Comparison of results of present study metals concentration with WHO/FAO Joint CODEX Alimentarius, maximum permissible levels

The levels of metals in the *Ficus sur* fruits and WHO/FAO permissible level are given in Table 9 (Codex Alimentarius Commission, 2011). The study shows that in general, the concentration of Cd and Pb metals were found at elevated levels as

compared to WHO/FAO for the *Ficus sur* fruits. This high level of Cd and Pb might be due to the use of Cd and Pb containing phosphate fertilizers. On the other hand, the concentration of Zn and Cu was found within the maximum limits set by the FAO/WHO for this *Ficus sur* plant fruits. The concentration of K, Ca, Mg, Fe and Mn are within the permissible levels.

Table 9. Comparison of results of the present study metals concentration (mg/kg) with WHO/FAO Joint CODEX Alimentarius Commission (2011) maximum permissible levels (mg/kg).

Parameters	Maximum permissible levels of metals (mg/kg)								
	Zn	Cu	Pb	Cd	Mn	Fe	Mg	K	Ca
WHO/FAO Joint CODEX Alimentarius Commission (2011)	50	40	0.3	0.2	-	-	-	-	-
<i>Ficus sur</i> fruit	24.6	7.47	4.62	1.15	14.2	444	787	13029	4580

CONCLUSION

The present study determined levels of essential (K, Ca, Mg, Fe, Zn, Cu, Mn) and toxic metals Cd and Pb in *Ficus sur* fruits and its corresponding soil from three different areas of Ethiopia. The determinations of metals were performed using MP-AES. The concentration of Cd was found below the detection limit in all soil samples. The investigation of the metal levels revealed that for most of the metals determined, there was a direct

relationship between the levels of metals in the *Ficus sur* fruits and those in the soil in which the plant was grown. The study also showed that the metals were present at different concentrations in the samples from different sites. Comparable results were found with some of the values reported in the literature. Cd and Pb concentrations slightly exceeded the permissible levels by WHO/FAO. The bioavailability of the metal in the plant was checked by analysis of soil pH; soil organic matter and soil electrical

conductivity. The study also showed the metal accumulation factor from soil to plants.

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