Int.J.Curr.Res.Aca.Rev.2020; 8(10): 8-13

International Journal of Current Research and Academic Review

ISSN: 2347-3215 (Online) Volume 8 Number 10 (October-2020)

Journal homepage: http://www.ijcrar.com

doi: https://doi.org/10.20546/ijcrar.2020.810.002

Assessment and Mapping of Some Soil Micronutrients Status in Agamsa Watershed, Ethiopia

Moges Tadesse[1*], Haile Getnet[1], Bobe Bedadi[2] and Tesfaye Feyisa[3]

[1]*Woldia University, Department of Soil and Water Resource Management, Ethiopia. P.O.Box 400*
[2]*Haramaya University, School of Natural Resources Management and Environmental Sciences, Ethiopia*
[3]*Amhara Region Agricultural Research Institute (ARARI), soil and water research director, Bahir Dar, Ethiopia*

**Corresponding author*

Abstract

Despite being required in small quantities, micronutrients are important for sustainable crop growth, and their deficiency and toxicity can affect crop yield. However, fertilizer recommendation for crops in Ethiopia is mainly for macronutrients. Nitrogen and phosphorus in the form of urea and DAP are the major fertilizers applied by smallholder farmers in the country. But, continuous applications of only macronutrients may cause rapid depletion of micronutrients in the soil. Therefore, this study was conducted to assess the status of micronutrients and map its spatial distributions in Agamsa watershed, Ethiopia. Accordingly, nine composite soil samples were collected from the surface soil layer (0-30cm) for the analysis of micronutrients iron (Fe), manganese (Mn), zinc (Zn), and copper (Cu). These micronutrients were extracted with diethylene triamine pentaacetic acid (DTPA) and then determined by atomic absorption spectrophotometer in comparison with standards at 248.3nm, 279.5nm, 324.7nm, and 213.9nm wavelengths for Fe, Mn, Cu, and Zn, respectively. Arc Map 10 with the spatial analyst function of ArcGIS software was used to prepare nutrient maps. The study shows that the concentrations of extractable Fe, Mn, Zn, and Cu ranged from 7.25 to 16.55, 5.62 to 15.47, 0.7 to 5.70, and 1.66 to 4.12mg kg^{-1}, respectively. Based on the soil nutrients critical values, the concentrations of extractable Fe, Mn, Zn, and Cu were found to high, medium, medium to high, and low to medium, respectively. To strengthen this result, future research should focus on plant sample analysis and calibration of micronutrients with plant response.

Article Info

Accepted: 10 September 2020
Available Online: 20 October 2020

Keywords

Assessment; Micronutrients; Mapping; Critical level

Introduction

Most sub-Saharan Africa (SSA) soils are naturally less fertile (Lelago *et al.*, 2016). This is probably due to nutrient mining from continuous cultivation and low external input of nutrients causing the soil fertility decline (Karltun *et al.*, 2013a). As a result, agricultural productivity per unit area of land is declining through time and food production could not keep pace with population growth (Roy *et al.*, 2003). Low nutrient content in the parent material from which the soils were derived, the imbalance between nutrient inputs and outputs, nutrient loss by erosion, and lack of balanced fertilization are the major threats to agricultural productivity in Ethiopia (Tena and Beyene, 2011). The fertilizer usage in the country is also mainly subjective without being based on the crop need, soil nutrient dynamics, and agroecological factors and using a blanket rate of application (Kidanemariam, 2008). For instance, in most parts of Ethiopia, farmers apply 100 kg ha^{-1} DAP and 50 kg ha^{-1} Urea which supply only N and P irrespective of soil heterogeneity (Lelago *et al.,* 2016). Continuous applications of only these nitrogen (N) and phosphorous (P) containing fertilizers have resulted in micronutrient depletions. As stated by Katyal and Randhawa (1983) two to sixtimes more of the micronutrients are being removed annually through crop harvest from the soil, than are applied to it when using high analysis fertilizers like DAP and Urea. Micronutrient problems are expected to increase in the future because of the increase in cropping intensity, the use of high yielding varieties, and the more extensive use of N, P and potassium fertilizers(Tilahun *et al.,* 2015).Therefore, knowledge about an up-to-date status of soil micronutrients at different landscapes and mapping their spatial distribution play a vital role in site-specific fertilizer recommendation to enhance agricultural productivity on the sustainable basis. Therefore, this study was conducted with specific objectives to assess the status of soil micronutrients and mapping its spatial distribution soil in Agamsa watershed, Ethiopia.

Materials and Methods

Description of the study area

The study was conducted at Agamsa sub-watershed, which is located in Habru District of Northeastern, Ethiopia (Figure 1). Geographically, the study area lies between 11^0 38' 35.99" to 11^0 40' 16.86" N latitude and 39^0 37' 3.76" to 39^0 39' 43.51" E longitude with an altitude ranging from 1564 to 2038 meters above sea level. The total area of the watershed is about 523 ha and is characterized by flat and hilly topography. The study area is characterized by a bimodal rainfall pattern. The short (*Belg)* rain starts in February and ends in April while the main rainy (*kiremt*) season starts in June and ends in September with the erratic distribution. Its land use is mainly subsistence rain-fed agriculture and has a mean annual rainfall of 500-950 mm and a mean annual temperature of 14 -31°C. The existing land use system consists of 47.34% (247.59 ha) cultivated land and 52.66 % (275.4ha) shrublands. The smallholder farmers practice a mixed farming system that integrates both crops and livestock. Farmers use specific soil fertility management strategies for their farms. However, most of them apply the blanket recommendation of mineral fertilizer (100 kg/ha DAP and 50 kg/ha Urea) to their fields. As far as crop residue management is concerned, farmers of the study area were not well aware of the advantage of returning crop residues for soil fertility management. Hence, crop residues are collected for animal feed and fuel.

Soil sample collection and analysis

Field data collection and soil sampling were carried out by considering the slope variation and fertility gradients of the study area. Representative soil samples were collected from each sampling site at a depth of 0 to 30 soil layers. For each sampling site, a minimum of 10 to 15 subsamples was collected and composited within 50 m distance between two sampling points using a random sampling technique. At each sampling site, a GPS (Global Position Systems, Garmin 76x model) reading was used in taking the coordinates. As a result, a total of nine composite soil samples were collected, by using Edelman auger at the surface layer, for the analysis of soil physical and chemical properties. Then the collected soil samples were air-dried, gently crushed with mortar and pestle, mixed well, and passed through a 2-mm sieve. Then, approximately one kg of the composited fine soil sample was transported for analysis at Water Works Design and Supervision Enterprise, Addis Ababa, following the standard procedures. Finally, extractable micronutrients (Fe, Mn, Cu, and Zn) were extracted with diethylene triamine pentaacetic acid (DTPA) as described by Okalebo *et al.,* (2002) and then determined by atomic absorption spectrophotometer (AAS) in comparison with standards at 248.3 nm, 279.5 nm, 324.7 nm and 213.9 nm wavelengths for Fe, Mn, Cu, and Zn, respectively. Similarly, soil particle size distribution was analyzed by Bouyoucos hydrometer method (Bouyoucos, 1962) after dispersing the soil particles with sodium hexametaphosphate ($NaPO_3$).The pH (H_2O) of the soil was measured potentiometrically in the supernatant suspension of using a digital pH meter following the procedure outlined by van Reeuwijk (1986).

Mapping of soil micronutrients

Based on soil laboratory analysis results, soil fertility indices were generated and ratings were made; and the soils were classified into different fertility categories, i.e., very low, low, medium, high, and very high based on the content of each selected soil parameter. Arc Map 10 with the spatial analyst function of Arc GIS software was used to prepare soil fertility maps and soil test values at other locations were interpolated using a geostatistical technique of ordinary Kriging (OK). Hence, the spatial distribution of extractable micronutrients (Cu, Zn, Fe, and Mn) was carried out separately for each element with the 3D Analyst/ Raster Interpolation / Ordinary/ Kriging/ tools in Arc Map 10.

Statistical analysis

Descriptive statistics were carried out with the help of Statistical Analytical Software (SAS) version 9.2 to reveal the magnitude of selected soil physicochemical properties.

Results and Discussions

The status of soil micronutrients is strongly influenced by soil pH and soil texture. The minimum and maximum values of soil pH (pH_H_2O) in the study area were 5.8 and 6.71, respectively (Table 1). As per the pH ratings suggested by Karltun *et al.*, (2013b), 77.78% of the soil samples in the study area were rated as moderately acidic (5.6- 6.5) while 22.22%, were neutral (6.6- 7.3). The variation in soil pH might be due to differences inland use type and removal of basic cations by crop harvest (Emiru and Gebrekidan, 2013). Since, most nutrients are available for field crops at pH value of between 5.5 and 7.5 (Gazey and Davies, 2009), the pH values of soils in the study area are most suitable for plant growth and the availability of most plant nutrients might not be affected with this pH ranges. The results of the study also revealed that there were no textural differences within the soils of the study area. Accordingly, all the soils had clay loam textural class with the mean percentage value of 33.88, 31.66, and 34.44, for sand, silt, and clay respectively (Table 1). The minimum sand, silt, and clay contents of the soil samples were 31%, 27.5%, and 32%, while the maximum contents were 37.5%, 35%, and 37.5% respectively (Table 1). Hence, clay fraction followed by sand and silt dominates the soils of the study area. Although the texture is an inherent soil property, differences in particle size distribution might be indirectly attributed to farming practices such as continuous tillage and removal of soil by erosions (Tilahun, 2007). The variations also might be due to the slope gradient difference, since the removal of the finer particles by erosion is enhanced on the upper slope areas while deposition occurs on the lower slope (Aytenew and Kibret, 2016).

The concentrations of extractable micronutrients in the studied area were found to be in the order of Fe>Mn> Cu>Zn (Table 2). The concentrations of extractable Fe in the study area ranged from 7.25 mg $kg^{-1}$to 16.55 mg kg^{-1} with a mean value of 12.24 mg kg^{-1}. According to the ratings of Jones and Benton (2003), all soil samples in the study area were rated into high range (Figure 1). Based on the critical limit of 4.5 mg kg^{-1}(Lindsay and Norvell, 1978), all soil samples have sufficient available iron, and iron deficiency is unlikely for any crop grown on these soils. Moreover, the value of extractable Fe is within the adequate range for most of the crops; since the threshold level of soil DTPA extractable Fe is 4.5 to 20 mg $kg^{-1,}$and toxicity of Fe exists only when its value exceeds 20 mg kg^{-1}(Lindsay and Norvell, 1969). The result is in accordance with the previous studies in Ethiopia(Abate *et al.*, 2016, Aytenew and Kibret, 2016, Kibret and Asfaw, 2014, Nigussie and Kissi, 2012) indicating that Fe deficiencies are not common and even its concentrations are above the critical level in many parts of the country. Sufficient available Fe in the study area, therefore, can be induced by clay loam texture, low available phosphorous and low Cu concentration, slightly acidic condition of the soil, the optimum concentration of extractable Zn and Mn in the soil.

Similarly, the concentrations of extractable Mn in the study area varied from 5.62-15.47 mg kg^{-1} with a mean value of 7.29 mg kg^{-1} (Table 2). Based on the ratings ofRansom (2004), all the soil samples in the study area were rated into medium range (Figure 1). According to the critical level of 1mg kg^{-1} suggested by(Lindsay and Norvell, 1978), all the collected soil samples within the study area were categorized under sufficient in available manganese. Besides, the concentrations of extractable Mn is within the adequate range for most of the crops; since the threshold level is 1 to 48 mg kg^{-1} and toxicity of Mn exists only when its value exceeds 48 mg kg^{-1} (Lindsay and Norvell, 1969).This finding is in agreement with Nigussie and Kissi (2012)and Asgelil *et al.*, (2007)who independently reported that extractable Fe and Mn levels were usually adequate and above the critical limits in different parts of Ethiopian soils. Available Cu content, on the other hand, varied from 1.66 mg kg^{-1} to 4.12 mg kg^{-1} with a mean value of 2.61 mg kg^{-1}. Based on ratings of Ransom (2004), 45.45% of the soils of the study area are classified as low and 55.55% medium in Cu content (Figure 1). However, based on the critical limit of 0.6 mg kg^{-1} (Lindsay and Norvell, 1978), all soil samples have sufficient available Cu and Cu deficiency is unlikely for any crop grown on these soils. Cu availability is dependent on soil OM, soil reaction (pH), and other macro and micronutrient interactions (Solberg *et al.*, 1999). The medium Cu content in soils is, therefore, ascribed to soils low in organic matter, total nitrogen, and available phosphorous content while, the low Cu content might be due to high level of Fe and Mn and exposed surface soil due to erosion (Sanginga and Woomer, 2009). Moreover, Cu is more likely available between the 5.0 and 7.0 pH range (Sanginga and Woomer, 2009), and hence, the pH of soils in the study area is within the acceptable range for Cu availability. The extractable Zn in soils varied considerably and ranged from 0.7 to 5.7 mg kg^{-1} in the study area. The mean value of 2.96 mg kg^{-1} of the available Zn was more than the critical limit of Zn (0.6 to 1 mg kg^{-1}) as suggested by Lindsay and Norvell (1978) Based on ratings of Ransom (2004), 11.12 % the soil sampling units in the study area were classified as medium and 88.88 % high in Zn content (Figure 1). Availability of Zn decreases with increasing soil pH due to increased adsorptive capacity, high organic matter content contents due to the formation of stable organic complexes with the solid-state, high levels of phosphorous and with higher concentrations of Cu in the soil solution relative to Zn (Alloway, 2008). But in the study area the reverse is true, i.e. the contents of organic matter, available phosphorous and extractable Cu are low to medium and the range of pH (5.8 to 6.71) in the study area is within the acceptable range for Zn availability. Hence, deficiency of Zn is unlikely to occur and Zn is adequately available in the study area.

Table.1 Soil pH and soil particle size distribution in the study area

S/point	Sand (%)	Silt (%)	Clay (%)	Textural	Soil pH	Land use types
1.	31.0	33.5	35.5	Clay loam	6.71	Cultivated land
2.	34.5	31.5	34.0	Clay loam	6.23	Cultivated land
3.	35.5	27.5	37.0	Clay loam	6.71	Cultivated land
4	33.0	33.5	33.5	Clay loam	6.29	Cultivated land
5.	32.0	32.5	35.5	Clay loam	6.28	Cultivated land
6.	32.0	30.5	37.5	Clay loam	6.21	Cultivated land
7.	37.5	30.0	32.5	Clay loam	6.13	cultivated land
8.	32.5	35.0	32.5	Clay loam	6.21	cultivated land
9.	37.0	31.0	32.0	Clay loam	5.80	Shrub land
Mean	**33.80**	**31.66**	**34.44**		**6.28**	

Table.2 The DTPA extractable micronutrients (Fe, Mn, Cu, and Zn) status in the study area

	Extractable micronutrients				Land-use type
S/point	Fe	Cu	Mn	Zn	Cultivated land
1	13.11	2.56	9.31	0.7	Cultivated land
2	16.55	1.66	7.18	2.4	Cultivated land
3	11.65	2.34	6.43	2.08	Cultivated land
4	15.22	2.09	5.68	2.48	Cultivated land
5	12.35	2.14	5.62	3.11	Cultivated land
6	7.87	2.23	5.71	1.18	Cultivated land
7	10.33	2.86	7.81	4.88	Cultivated land
8	7.25	3.47	8.1	4.09	Cultivated land
9	15.81	4.12	15.4	5.7	Shrubland
Mean	**12.24**	**2.61**	**7.29**	**2.96**	

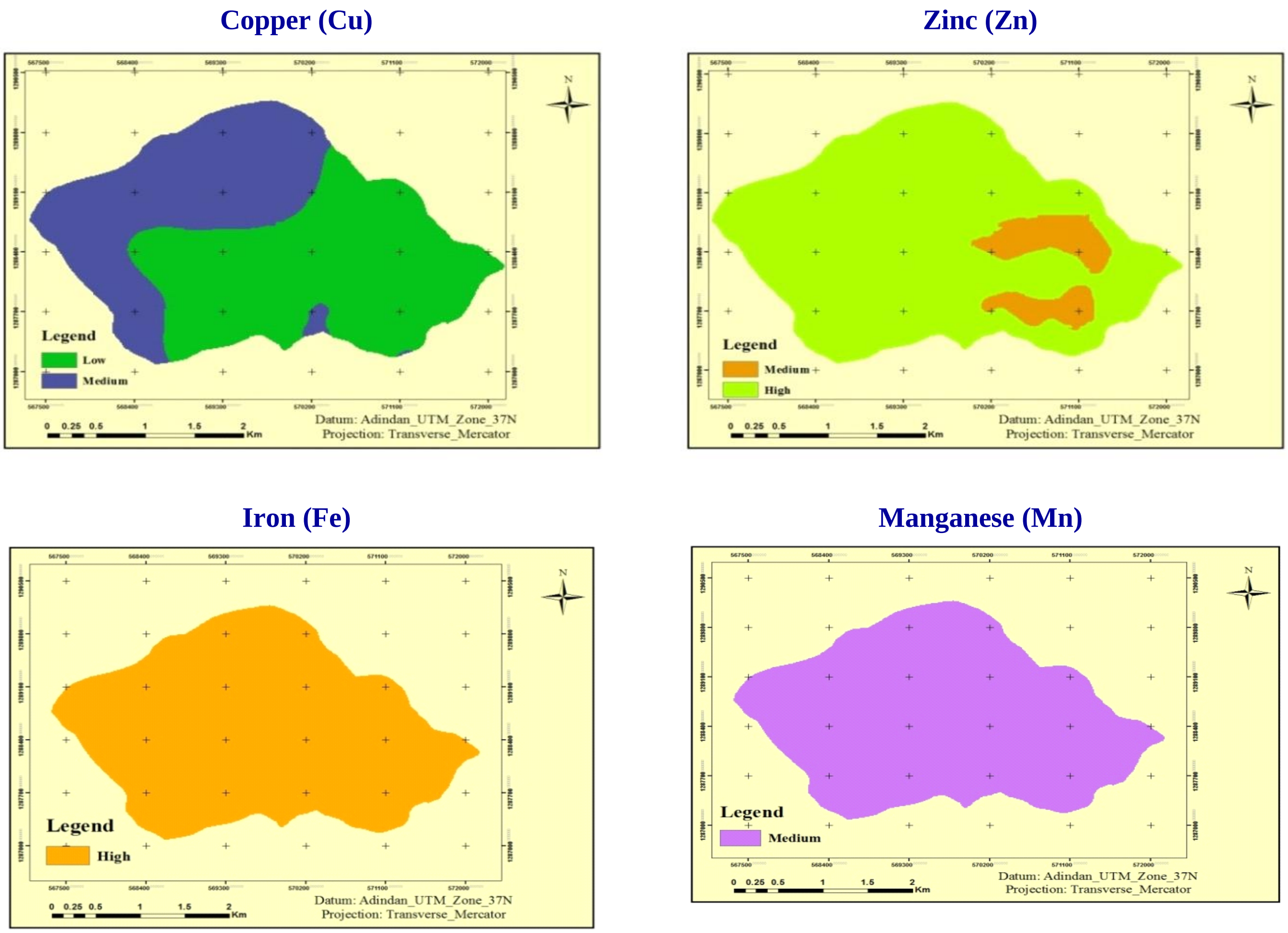

Figure.1 Spatial distribution of soil micronutrients (Cu, Zn, Fe, and Mn) in Agamsa Watershed

Conclusion and recommendations are as follows:

Soil nutrients depletion is one of the major challenges to boost crop production and productivity in Ethiopia. The suitability of the soil for crop production depends on its fertility level, which is evaluated based on the quality of the soil's physical, chemical, and biological properties. Without detailed soil-related information at a specific local level, sustainable crop production and soil resource maintenance could not be achieved. Therefore, this study was conducted with the objectives of assessing the status of soil micronutrients and mapping its spatial distribution in Agamsa watershed, Ethiopia.

The results of the study revealed that there were no textural differences within the soils of the study area. Accordingly, all the samples had clay loam textural class with a mean percentage value of 33.88, 31.66, and 34.44, for sand, silt, and clay, respectively. Based on the critical levels suggested, 77.78% of the soil samples in the study area were rated as moderately acidic (5.6-6.5) while 22.22%, were neutral (6.6-7.3). Based on the result of the analysis, the concentrations of extractable Fe, Mn, Zn, and Cu were found to high, medium, medium to high, and low to medium, respectively. From this study, it can be concluded that locally tested and adopted critical levels for all nutrients need to be developed to make sure that these findings are well done. Besides, future research should focus on the periodic assessment of soil nutrients to obtain the maximum yield.

References

Abate, K., Mohammed, M. and Kibret, K. 2016. Soil fertility assessment and mapping of spatial variability at Amareganda-Abajarso sub-watershed, north-eastern Ethiopia. *East African Journal of Sciences*, 10, 1-14.

Alloway, B. J. 2008. Zinc in soils and crop nutrition.

Asgelil, D., Taye, B. and Yesuf, A. 2007. The status of micro-nutrients in Nitisols, Vertisols, Cambisols, and Fluvisols in major Maize, Wheat, Teff, and

Citrus growing areas of Ethiopia. *Proceedings of Agricultural Research Fund*, 77-96.

Aytenew, M. and Kibret, K. 2016. Assessment of soil fertility status at dawja watershed in Enebse Sar Midir district, Northwestern Ethiopia. *International Journal of Plant & Soil Science*, 11, 1-13.

Bouyoucos, G. J. 1962. The hydrometer method improved for making particle size analyses of soils 1. *Agronomy Journal*, 54, 464-465.

Emiru, N. and Gebrekidan, H. 2013. Effect of land-use changes and soil depth on soil organic matter, total nitrogen, and available phosphorus contents of soils in Senbat Watershed, Western Ethiopia. *ARPN Journal of Agricultural and Biological Science*, 8, 206-2012.

Gazey, C. and Davies, S. 2009. Soil acidity: A guide for WA farmers and consultants.

Karltun, E., Lemenih, M. and Tolera, M. 2013a. Comparing farmer's perception of soil fertility change with soil properties and crop performance in beseku, Ethiopia. *Land Degradation and Development*, 24, 228-235.

Karltun, E., Mamo, T., Bekele, T., Gameda, S. and Kidanu, S. 2013b. Towards improved fertilizer recommendations in Ethiopia—nutrient indices for categorization of fertilizer blends from EthioSISworeda soil inventory data. *Addis Ababa, Ethiopia*.

Katyal, J. and Randhawa, N. 1983. Micronutrients. FAO Fertilizer and plant nutrition. *Bulletin*, 7.

Kibret, K. and Asfaw, M. M. 2014. Fertility mapping of soils in Cheha Woreda, Gurage zone, southern Ethiopia. Haramaya University.

Kidanemariam, A. 2008. Recommendation of Phosphorus fertilizer based on soil-test and response of tef to nitrogen and Phosphorus Fertilizers. *Ethiopian Journal of Natural Resources.*

Lelago, A., Mamo, T., Haile, W. and Shiferaw, H. 2016. Assessment and Mapping of Status and Spatial Distribution of Soil Macronutrients in Kambata Tembaro Zone, Southern Ethiopia. *Adv. Plants Agric. Res*, 4, 144.

Lindsay, W. and Norvell, W. Development of a DTPA micronutrient soil test. Agron. Abstr, 1969. 1-11.

Lindsay, W. L. and Norvell, W. 1978. Development of a DTPA soil test for zinc, iron, manganese, and copper 1. *Soil science society of America Journal*, 42, 421-428.

Nigussie, A. and Kissi, E. 2012. Physicochemical characterization of Nitisol in Southwestern Ethiopia and its fertilizer recommendation using NuMaSS. *Global Advanced Research Journal of Agricultural Science*, 1, 66-73.

Okalebo, J. R., Gathua, K. W. and Woomer, P. L. 2002. Laboratory methods of soil and plant analysis: a working manual second edition. *Sacred Africa, Nairobi*, 21.

Ransom, J. K. 2004. Agronomic Handbook: Management of Crops, Soils, and their Fertility: JB Jones, Jr.; CRC, Boca Raton, 2003, 450 pages, hardback, ISBN 0-8493-0897-6, US $99.95. *Agricultural Systems*, 79, 257-258.

Roy, R. N., Misra, R. V., Lesschen, J. P. and Smaling, E. 2003. Assessment of soil nutrient balance: approaches and methodologies, Food and Agriculture Org.

Sanginga, N. and Woomer, P. L. 2009. Integrated soil fertility management in Africa: principles, practices, and developmental process, CIAT.

Solberg, E., Evans, I. and Penny, D. 1999. Copper deficiency: Diagnosis and correction. *Agri-facts. Soil Fertility/Crop Nutrition. Alberta Agriculture, Food and Rural Development, Agdex*, 532-3.

Tena, W. and Beyene, S. 2011. Identification of growth-limiting nutrient (s) in alfisols: Soil physico-chemical properties, nutrient concentrations, and biomass yield of maize. *American journal of plant nutrition and fertilization technology*, 1, 23-35.

Tilahun, E., Kibret, K., Mamo, T. and Shiferaw, H. 2015. Assessment and Mapping of Some Soil Micronutrients Status in Agricultural Land of Alicho-Woriro Woreda, Siltie Zone, Southern Ethiopia. *American Journal of Plant Nutrition and Fertilization Technology*, 5, 16-25.

Tilahun, G. 2007. Soil fertility status as influenced by different land uses in Maybar areas of South Wello Zone, North Ethiopia. *MS. c Thesis, Haramaya University, Haramaya, Ethiopia. 40p*.

Van Reeuwijk, L. P. 1986. Procedures for soil analysis.

How to cite this article:

Moges Tadesse, Haile Getnet, Bobe Bedadi and Tesfaye Feyisa. 2020. Assessment and Mapping of Some Soil Micronutrients Status in Agamsa Watershed, Ethiopia. *Int.J.Curr.Res.Aca.Rev.* 8(10), 8-13.
doi: https://doi.org/10.20546/ijcrar.2020.810.002