American Journal of Agriculture and Forestry
2023; 11(2): 37-44
http://www.sciencepublishinggroup.com/j/ajaf
doi: 10.11648/j.ajaf.20231102.11
ISSN: 2330-8583 (Print); ISSN: 2330-8591 (Online)

Assessment of Nutrient Contents of Compost Prepared by Farmers in BunoBedele Zone, South Western Oromia, Ethiopia

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To cite this article:
Dechasa Mengistu, Gedefa Sori, Abdulmalik Mohammed. Assessment of Nutrient Contents of Compost Prepared by Farmers in BunoBedele Zone, South Western Oromia, Ethiopia. *American Journal of Agriculture and Forestry*. Vol. 11, No. 2, 2023, pp. 37-44. doi: 10.11648/j.ajaf.20231102.11

Received: December 30, 2022; **Accepted**: March 8, 2023; **Published**: March 21, 2023

Abstract: This study was examined the nutrient content of compost prepared by farmers for soil fertility improvement and crop production. Heavy metal concentration in the compost was also investigated. The specific objectives were to asses and evaluate nutrient contents of farmers practiced composts prepared from diversified material sources and to make data base for composting processes. A total 213 samples were collected from Bedele, Gechi and Dabo district by random sampling methods from a representative sites. The pH, moisture content, OC, TN, C:N ratio, exchangeable Ca and Mg, Available P, EC, Mn, Fe, Cu and Znwere analyzed according to a standard laboratory procedure. An average OC and OM content of farmer practiced composts were 10.1, 13.9 and 12.1% and 18.9, 23.96 and 20.86% in Bedele, Gechi and Dabo Hana respectively. An average Moisture content of compost prepared in the study areas were 7.2, 7.6 and 6.2 for Bedele, Gechi and Dabo Hana respectively. Moisture content of compost prepared in these three districts were below the standard range. This may be caused due to the problem of watering during compost preparation. An average electric conductivity of composts were 1.5, 1.1 and 1.2 in Bedele, Gechi and Dabo Hana disticts respectively. The majority of the macro and micronutrients were analyzed for compost collected from Bedele, Gechi and Dabo Hana district were below the recommended range. This is due to unbalanced substrate during compost preparation especially absence of legume materials or residue from mixing materials.

Keywords: Composting, Macronutrient, Micronutrient and Heavy Metals

1. Introduction

The performance of husbandry depends on natural factors and the intensity of agricultural inputs [5]. The vast area of Africa in general and Ethiopia in particular is characterized by low soil fertility, high soil declination, rain-fed and disintegrated land holding, extremely low external inputs similar as toxin and agro-chemicals, and the use of traditional husbandry ways [14]. In sustainable and intertwined crop product systems the addition of compost proved to have significant effect on volume and quality of crop products [29], [13]. Irrespective of its significance in integrated soil fertility operation, compost application among growers in Ethiopia is veritably limited. Growers are apprehensive of the benefits that could be attained from use of composts, but they don't have a simple to use and health system of composting [23] which accompanied by seasonal agrarian conditioning burdens them to use the conventional system of composting.

Many studies indicate that the use of compost on land may ameliorate several plant and soil parameters, thereby making compost an intriguing option for soil restoration purposes, while taking advantage of its fertilizer parcels [27]. Compost is stylish overall for soil correction that farmers can use to increase the quality and the health of soil [21]. Compost provides soil with nutrients, organic matter, and beneficial microorganisms, which can ameliorate crop health, growth, quality, and yields [28].

Composting is a system of enhancing natural decomposition process, through balanced carbon to nitrogen ratio (C:N) of raw organic materials that should be supplied with acceptable moisture and oxygen to intensify the exertion of putrefying microorganisms [23]. Composting process requires some requirements and knowledge on the putrefying organic waste materials such the C:N ratio to duly mix a desirable proportion of organic residue in the compost pile [23]. In the compost pile mixes when the C:N rate goes advanced or lowers the composting process will be hindered or may be stopped at each [11]. It's veritably important to keep the C:N of the compost pile in the range between 25:1 and 35:1. Still, C:N higher than 35 would lower addition of putrefying microorganisms due to deficit of N to conflation their body protein. And C:N lower than 25 results in product of high quantum of ammonia by microorganisms, which also beget lower pH, reduced degradation and unwelcome odor of the compost [19].

Monitoring and controlling the water content, oxygen position, and temperature of the composting process is also another important issue to have good quality and large volume compost within listed time asked [23]. On the other hand type of raw accoutrements, their proportions in the pile and the style of composting significantly affect the controllability of composting (rate of degradation) and the quality of the compost. To have a controlled composting process and good quality compost the choice of composting style is pivotal [20]. The quality of compost is determined by the nutrient composition, attention of heavy metals, presence of inert materials, addition of weed seeds, pathogenic bacteria and compost maturity [6]. Therefore, a good quality compost will have a dark brown color and maturity indicator (ammonia to nitrate (NH_3: NO_3) and CN) rate in the range of 0.5 to 3 and less than 25, independently [31]; hile having less accumulation of heavy metals, weed seeds and pathogenic bacteria [6].

As the price of inorganic fertilizer getting precious from time to time, growers are inclined toward using compost for crop production. It isn't the quantum of compost that applied to the soil, but the quantum of nutrients supplied to the crop that determines the position of crop productivity. Also the use of compost must be depending on the required materials used for compost preparation rather than the bulk amount of compost applied to soil [24]. It is a necessity to know nutrient composition of any material used for fertility enhancement, and composts must be justified with laboratory test to know the initial soil nutrient status, nutrient content of compost used at each cropping time based on the type of composting material sources, and the demand of addition of chemical fertilizer addition to get the targeted yield eventuality of crop types in use, i.e., integrated nutrient amendment is essential for our current soil fertility situations rather than single fertilizer source [16]. Therefore an assessment was initiated with the specific objectives were: to asses and estimate nutrient contents of growers rehearsed composts prepared from diversified material sources and to identify the gap and giving the directions for composting processes.

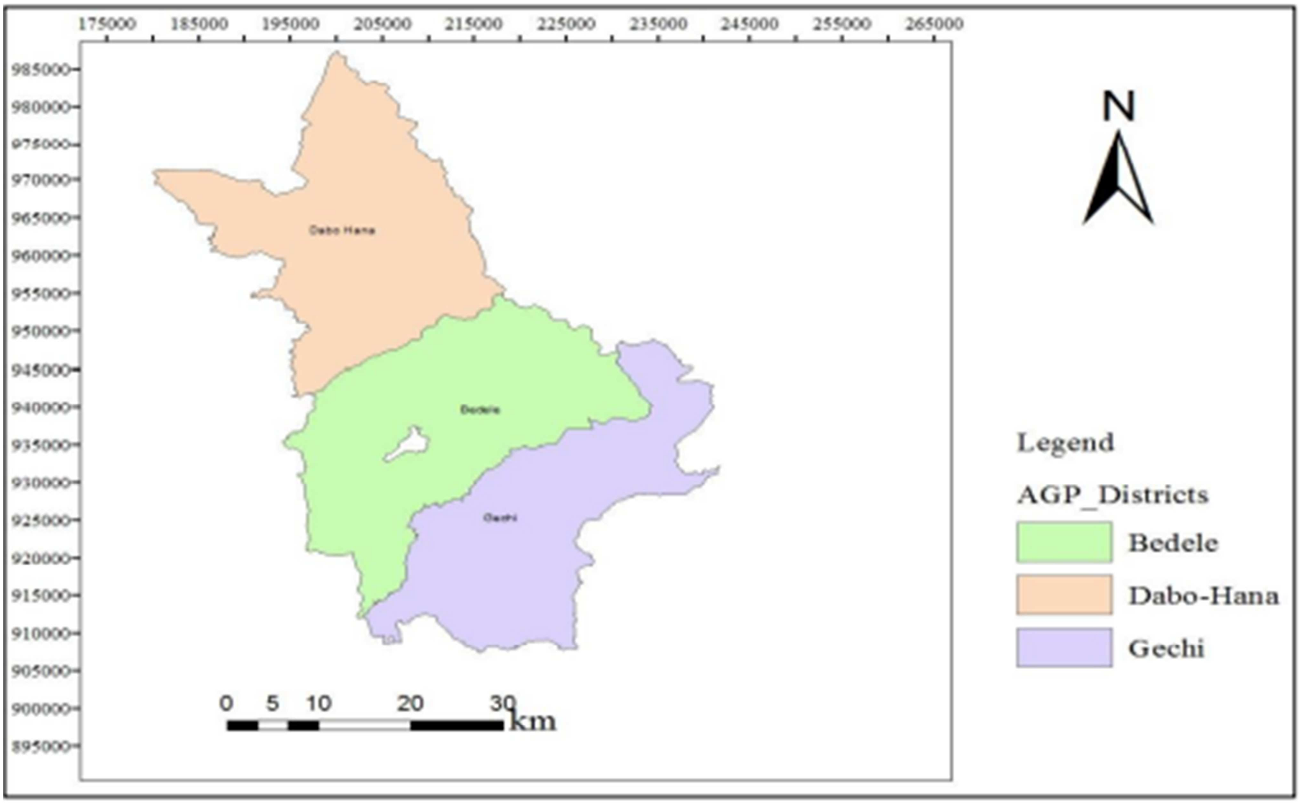

Figure 1. *Location map of the study areas.*

2. Materials and Methods

2.1. Description of the Study Site

Bedele, Dabo Hana and Gechi districts are one of the agricultural potential areas selected by the AGP beneficiary districts of Oromia region. They are located in the western part of Oromia, on the main road to Metu, 60 kilometers (km) away from a zonal town (Bedele), and 420 km away from Addis Ababa. The districts are located between 8° 14'30"N to 8° 37'53"N, 8° 30'28.721"to 8° 41'34.595"N and 8° 14'34.56" to 8° 25'39.77"N latitude and 36° 13'17"E to 36° 35'05"E, 36° 26'19.157" to 36° 30'41.101" E and 36° 24'59.04" to 36° 35'14.19" longitude at Bedele, D-Hana and Gechi independently. The husbandry system then's characterized by timber coffee-cereal-beast mixed husbandry system. There are two distinct seasons in three sections the stormy season starting in late March and ending in October and the dry season from November to early March. The mean periodic temperature is 24.7°C and the downfall is frequently in excess of 1800 mm per annum. Many cereal crops, vegetables, beast, oil crops and coffee are under production and the downfall is veritably good in these implicit areas. The three districts have mounds, midland low-land agro-ecologies.

2.2. Procedure Used to Select the Districts and Farmers

This assessment of Nutrient Contents of Farmers Practices of Compost for Crop Production was conducted in different AGP beneficiary districts of Southwestern Oromia regional state such as Bedele, Gechi and Dabo Hana. A procedure used to select these three districts and 213 farmers first by grouping of administrative zones for the sake of compost samples collection and analysis like Buno Bedele Zone. Secondly we have been selected three of AGP beneficiary districts from this zone and we have selected ten kebeles per district and eight a representative farmers per kebele (i.e 3*10*8*1=240) was proposed. However, according to the accessibility only 213 compost samples were thoroughly collected from farmers practiced compost heap.

2.3. Collection of Raw Materials for Composting

According to information gathered during survey, various locally available organic materials were collected used as composting materials for all methods of composting. The organic/raw materials used were: sorghum leaves and stalks, kitchen scraps, tree leaves, broad leaved weeds, grass weeds, livestock manure, wood ash and saw dust were collected. Finally the common bulking agent top soil was taken from different fertile soil.

2.4. Sampling Method

Representative samples were taken from three points (at the beginning, middle and end of the pit). 500 gm composite samples were taken from all piles using polyethylene bag and transported by vehicle to Bedele Agricultural research center, soil laboratory. The samples were analyzed at analytical chemistry and soil laboratory. The samples were taken from each heap from all sides of the heap (i.e. from the bottom, top, left, right side and interior of the heap) by hand using gloves and by turning the heap to take the sample from the bottom of the heap and thoroughly mixed together to get a homogeneous and representative sample of the entire heap of composting.

2.5. Laboratory Methods Used for Compost Analysis

During the composting process the temperature of the compost was recorded for the first 30 days. The date of compost maturity was recorded when the compost assumed a dark brown color following their curing phase and confirmed by maturity index. Chemical characteristics of various compost samples analysis were carried out in the Bedele Agricultural Research Center, Soil Laboratory using standard procedure. The method used for the analysis of moisture content were (drying at 105°C to constant weight by gravimeter method [2]; The pH was measured potentiometrically using a digital pH-meter in the supernatant suspension of 1:2.5 soils to water ratio.; Electrical conductivity (1:2.5 water extract, digital conductivity meter); Calcium and magnesium was analyzed using atomic absorption spectrophotometer following an ammonium acetate extraction method and measured by using flame photometer [26]; was determined using the wet oxidation method. Organicmatter content was calculated from determined organic carbon using conversion factor 1.724 [18] and the C:N ratio of the compost was determined from the ratio of total organic carbon to total Nitrogen. Manganese, iron, copper and Zink were analyzed using atomic absorption spectro-photometer at JEG Lab and glass.

3. Results and Discussion

3.1. Compost pH

The pH value of compost is important since applying compost to soil may alter the soil pH and therefore have an effect on the vacuity of nutrients to plants. According to Bordna Mona recommendation, the agrarian compost should fall between ranges of pH from 6.9-8.3 as suggestion of relative stability, while values near 7.5 are most typical [8]. Most compost slightly alkaline after curing, but some may be slightly acidic due to properties of their feedstock. The average pH values of compost collected from Bedele, Gechi and Dabo Hana was 7.6, 7.7 and 8.1 (figure 2, Table 1, Table 2 and Table 3), independently. The analytical result of compost collected from Bedele, Gechi and Dabo Hana were agreed with the standard optimum range of compost [8]. Efforts will need to be made to lower the pH value of compost if it exceeds 6.9-8.3 range. Lowering the pH value of compost also help to reduce ammonia volatilization and reduce odors [31]. Still, low–pH composts are in numerous cases partly cured, and may contain elevated concentrations of organic acids. Organic acids are a routine derivate of decomposition beforehand in the composting process, but they should no longer be present at after stages.

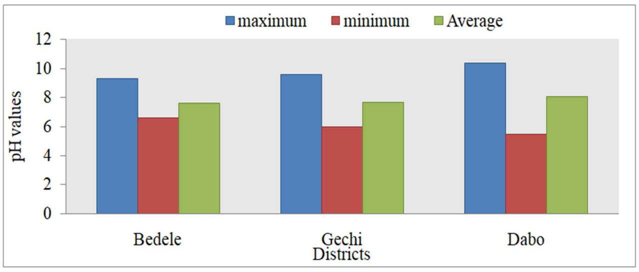

Figure 2. pH values of compost from three districts.

3.2. Organic Matter Content

Organic matter is an important component in all soils and has an important part to play in maintaining soil structure, nutrient vacuity and water holding capacity. It also serves as a vital role in maintaining healthy soil ecology [21]. It's generally expressed as a chance of dry weight of compost. There is no absolute value of organic matter, which is ideal for compost. Growers should make notes of the organic matter (OM) content of implicit soil amendments when comparing the price and qualities of different composts; it may range from 30-70% of OM [27].

The organic matter contents of compost collected from all spots were calculated from the average organic carbon content of the compost. According to the US composting council the normal range of organic matter content of compost collected from all spots were setup in the recommended range [27] (Figure 3). Composts that contain large quantities of inert materials, similar as soil, Silica, or ash, will not give as numerous benefits as compost that is richer in organic materials. For soil emendation, still, an upper limit of 65% OM is generally assessed, since materials with a greater organic matter may not be completely stable.

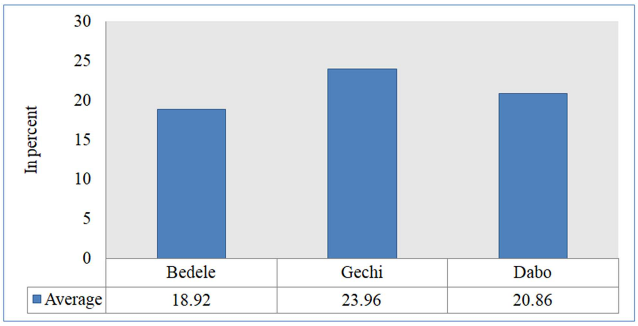

Figure 3. Organic matter contents of compost in the three districts.

3.3. Moisture Content

Moisture content is a measure of the quantity of moisture present in a compost sample and is expressed as a chance of fresh weight. Compost with low moisture content (<35%) may be too dry and dusty, irritating when handled. Compost with too high moisture content (>65%) can become too clumpy and difficult to transport which will limit its chances of being marketed as a quality product [27].

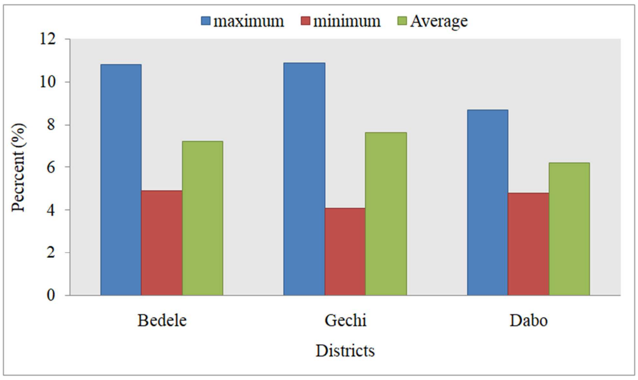

Figure 4. Average of moisture content (MC) of compost.

An optimum range of moisture for progressed compost was 35-55% [15]. Advanced moisture increased handling and transportation cost. An average moisture content of compost collected from Bedele, Gechi and Dabo Hana was 7.2, 7.6 and 6.2 independently (figure 3). The result revealed that it was bellow the optimal range of matured compost [15].

3.4. Electric Conductivity

Electric conductivity is a measure of the soluble salt content of compost in our case. Repeated addition of high salt compost may result in increases in soil salinity to levels that are toxic to salt sensitive plants but no problem in acidic or high rain fall area. Therefore the Electric conductivity of matured compost should only range from 1 to 3 mmho/cm [7]. According to this outer the average electric conductivity of the study area was matched with the optimal range. The average electric conductivity of Bedele, Gechi and Dabo Hana districts were revealed as 1.5, 1.1 and 1.2mmho/cm respectively (Figure 5). Estimation of the likely impact of compost on soil EC requires information on the compost application rate in tons per ha, along with soils texture, organic matter content and pre-compost EC [25].

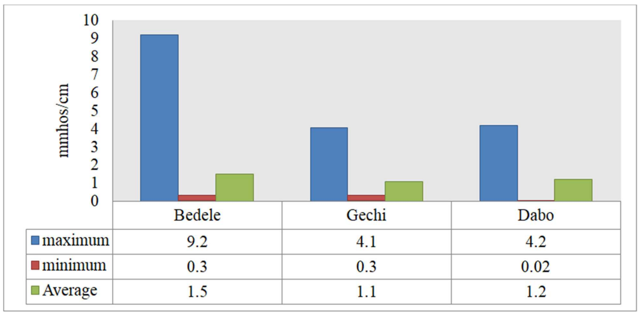

Figure 5. The Average of Electrical conductivity (EC) of compost.

3.5. Carbon to Nitrogen Ratio

When soil microbes decompose compost, they use its carbon for energy while immobilizing some nitrogen (N) to meet their own needs. Immobilized N is temporarily unavailable to plants until such as those microbes themselves decompose. The carbon-to-nitrogen (C:N) ratio is roughly proportional to the balance between the overall energy contained in the compost (carbon content) and the principal nutrient needed to decompose it, nitrogen, expressed as the total compost C divided by the total compost N [1]. According to Gej and Watso the C:N ratio of matured composts<20 to 1 [15], however, the results obtained from the study area showed that the C:N result in Bedele, Gechi and Dabo Hana were 16:1, 25:1 and 27:1 (Tables 1, 2 and 3) respectively. According to Gej and Watso an average C: N ratio of compost collected from Bedele district was agreed with the idea of Gej and Watso [15]. The low C:N ratio less than 20:1 may be expected to gradually mineralize nitrogen with little or no immobilization [9], whereas the C:N ratio of compost collected from Gechi and Dabo Hana were above the range stated by Gej and Watso [15].

3.6. Total Nitrogen Content

Compost can supply considerable nitrogen to soils. Compost ammonium and nitrate are available for plant uptake on application, while organic nitrogen has to be mineralized to ammonium, or at least decomposed to simple and soluble organic forms, before it can be taken up [21]. In general, high C:N ratio composts supply nitrogen more readily than low C:N composts, but specific mineralization rates cannot be predicted with any precision [21]. Because nitrogen is an important fertilizer, it is usually not toxic to crops at agronomic levels. High levels of ammonium can be phytotoxic, especially to seedlings, though susceptibility varies depending on the plant [7].

To report compost as having fertilizing capabilities and for it to be used in agriculture the TN content must be over 1% [4]. An average of total nitrogen content of compost collected from Bedele, Gechi and Dabo Hana was 0.8, 0.7 and 0.6% (Figure 6), respectively. The results were showed below the reference range (1.74 to 2.24%) as suggested by Woods end laboratory [30] and (1 to 2%) by Alexander [1]. The typical range of total nitrogen in compost is 1 to 3%, compost over 3% of total nitrogen is usually found to be immature and ammonical [4].

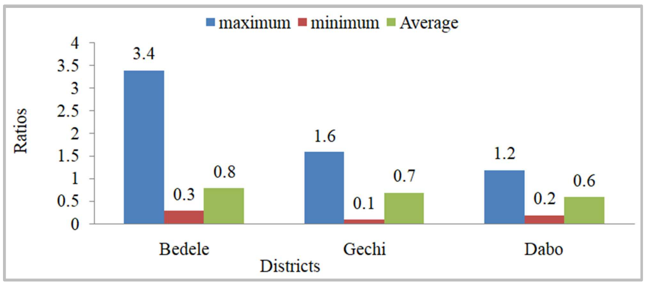

Figure 6. *The Average Total Nitrogen (TN) content of compost in percent.*

3.7. Organic Carbon Content

The most essential nutrients in composts are inorganic forms which are released slowly and are less subjected to leaching compared to inorganic fertilizers [13]. The incorporation of compost derived from biogenic household and garden waste to soil increases soil carbon and nitrogen concentration [17]. The average organic carbon content of compost in the study area was showed as 10.1, 13.9 and 12.1% for Bedele, Gechi and Dabo Hana District (Figure 7) respectively which was bellow the reference range>19.4 by Australian standard [3].

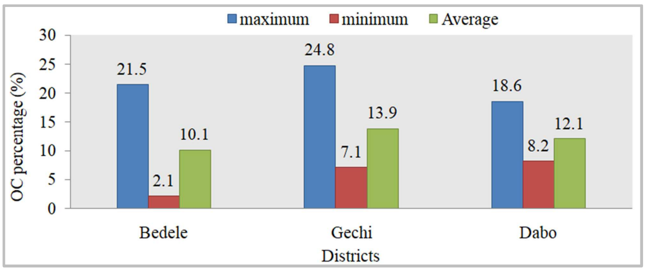

Figure 7. *Organic carbon content of compost in the three districts.*

3.8. Calcium and Magnesium Content

Calcium is act as bases when they exist as oxides, hydroxide and carbonate. Compost containing these bases when applied to soil, may counteract soil acidification varying pH levels and making soil nutrients more available to plants [12].

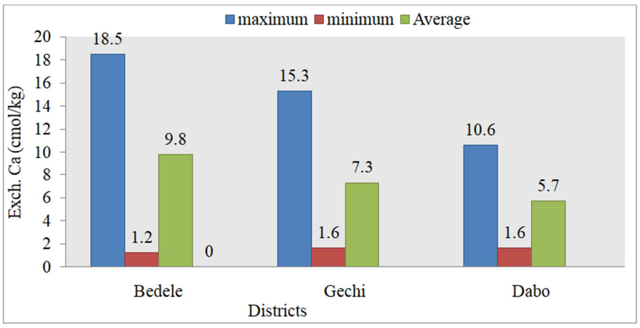

Figure 8. *Exchangeable calcium content of compost in the three districts.*

The average calcium in compost collected from three districts were 9.8, 7.3 and 5.7 cmol kg^{-1} for Bedele, Gechi and Dabo Hana (Figure 8, Tables 1, 2 and 3), respectively. According to the Canada laboratory standards the calcium content of compost collected from Gechi and Dabo district was below the ideal range of compost, while compost collected from Bedele district was agreed with the ideal range of compost. Ideal range of compost for exchangeable calcium is 8-13 $cmolkg^{-1}$ [10].

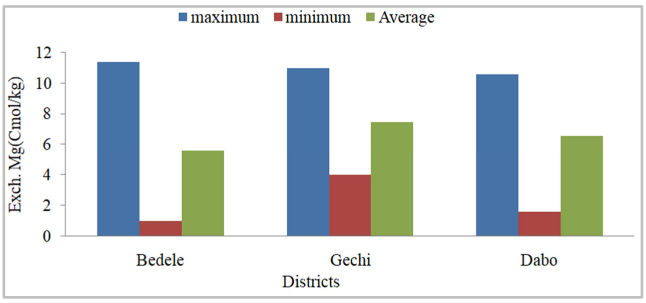

Figure 9. *Exchangeable magnesium content of compost in the three districts.*

Magnesium acts as bases when they exist as oxides, hydroxide and carbonate. Similar to calcium compost containing these bases, when applied to soil, may counteract soil acidification varying pH levels and making soil nutrients more available to plants [12]. The average of magnesium in compost for three district was 5.6, 7.5 and 6.6cmol kg^{-1} for Bedele, Gechi and Dabo Hana (Figure 9, Table 1, Table 2 and Table 3), respectively. The ideal range for exchangeable magnesium in compost is 1.2-8cmolkg^{-1} [10]. According to this standard the exchangeable magnesium of all three district were agree with the ideal range/optimum range [10].

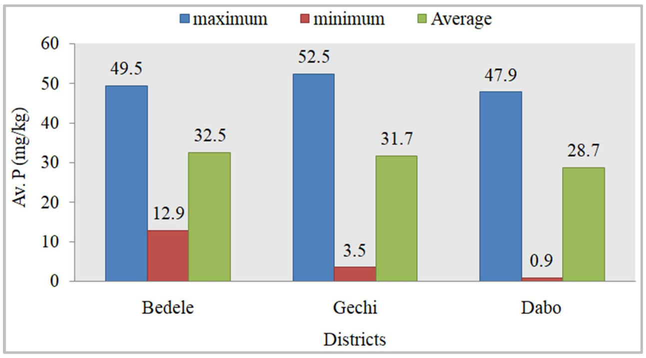

Figure 10. *Available phosphorous content of compost in the three districts.*

3.9. Available Phosphorous Content

Phosphorous availability from compost is much higher than nitrogen availability from compost [22]. The average available phosphorous in the compost samples were 32.5, 31.7 and and 28.7 for Bedele, Gechi and Dabo Hana (Tables 1, 2 and 3) independently.

3.10. Micro-Nutrients Content

Micro nutrients also required for crop production just like macro-nutrients; the only difference is micro nutrients are required in minimum amount. The micro-nutrients content of compost is just varied based on materials used for composting. Manganese increases seed germination rates and reduces time to harvest because it increases phosphorus and calcium availability to the crop. Zinc affects the rate of maturation of both seed and stalks. There is no ideal range established for micro nutrient content of compost yet. The maximum, minimum and average of micro nutrients analyzed for compost of Bedele, Gechi and DaboHan districts were listed on Tables 1, 2 and 3, respectively.

Table 1. *Summary of laboratory analysis results of farmers' composts collected from Bedele District.*

Parameters	Unit	Maximum	Minimum	Mean	Std. Deviation
pH (H_2O)	value	6.6	9.3	7.6	0.6
Moisture	%	4.9	10.8	7.2	1.1
EC	mmhos/cm	0.3	9.2	1.5	1.3
TN	%	0.3	3.4	0.8	0.5
OC	%	2.1	21.5	10.1	3.7
C:N	value	2.4	66.7	15.8	10.1
Ex.Ca	cmolkg^{-1} of compost	1.2	18.5	9.8	5.0
Ex.Mg	cmolkg^{-1} of compost	1.0	11.4	5.6	2.1
Av p	mgkg^{-1} of compost	12.9	49.5	32.5	9.7
Mn	mgkg^{-1} of compost	41.6	304.2	99.9	52.3
Fe	mgkg^{-1} of compost	3.3	186.4	65.0	43.4
Cu	mgkg^{-1} of compost	0.9	10.3	3.4	1.8
Zn	mgkg^{-1} of compost	4.8	42.3	14.2	7.9

Ec = Electric conductivity, TN = Total Nitrogen, Ex.Ca = Exchangeable calcium, Ex.Mg = Exchangeable Magnesium, OC = Organic Carbon.

Table 2. *Summary of laboratory analysis results of farmers' composts collected from Gechi District.*

Parameters	Unit	Maximum	Minimum	Mean	Std. Deviation
pH (H_2O)	value	6.0	9.6	7.7	0.8
Moisture	%	4.1	10.9	7.6	1.3
EC	mmhos/cm	0.3	4.1	1.1	0.8
TN	%	0.1	1.6	0.7	0.3
OC	%	7.1	24.8	13.9	3.8
C:N	value	12.7	55.9	24.7	9.3
Ex.Ca	cmolkg^{-1} of compost	1.6	15.3	7.3	2.9
Ex.Mg	cmolkg^{-1} of compost	4.0	11.0	7.5	1.7
Av p	mgkg^{-1} of compost	3.5	52.5	31.7	11.3
Mn	mgkg^{-1} of compost	11.2	128.0	70.3	33.0
Fe	mgkg^{-1} of compost	4.7	170.8	79.4	39.7
Cu	mgkg	1.4	10.3	3.0	1.2
Zn	mgkg	1.7	27.2	11.5	6.8

Ec = Electric conductivity, TN = Total Nitrogen, Ex.Ca = Exchangeable calcium, Ex.Mg = Exchangeable Magnesium, OC=Organic Carbon, Mn=Manganese, Fe = Iron, Cu = Copper and Zn stands for Zink.

Table 3. *Summary of the nutrients content of composts collected from Dabo Hana.*

Parameters	Unit	Maximum	Minimum	Mean	Std. Deviation
pH (H_2O)	value	5.5	10.4	8.1	1.0
Moisture	%	4.8	8.7	6.2	0.9
EC	mmhos/cm	0.0	4.2	1.2	1.0
TN	%	0.2	1.2	0.6	0.2
OC	%	8.2	18.6	12.1	2.2
C:N	value	7.4	86.7	27.4	17.0
Ex.Ca	cmolkg^{-1} of compost	0.8	11.6	5.7	2.2
Ex.Mg	cmolkg^{-1} of compost	1.6	10.6	6.6	2.2
Av p	mgkg^{-1} of compost	0.9	47.9	28.7	12.9
Mn	mgkg^{-1} of compost	21.9	304.2	91.9	48.8
Fe	mgkg^{-1} of compost	3.3	186.4	60.1	44.2
Cu	mgkg	1.7	10.3	3.9	1.6
Zn	mgkg	4.0	42.3	11.4	5.7

Ec=Electric conductivity, TN=Total Nitrogen, Ex.Ca=Exchangeable calcium, Ex.Mg=Exchangeable Magnesium, OC=Organic Carbon, Mn=Manganese, Fe=Iron, Cu=Copper and Zn stands for Zink.

Table 4. *Summary of the nutrients content of composts collected from the three districts.*

Parameters	Unit	Minimum	Maximum	Mean	Std. Deviation
pH (H_2O)	value	5.5	10.4	7.8	0.8
MC	%	4.1	10.9	7.0	1.2
EC	mmhos/cm	0.0	9.2	1.3	1.1
TN	%	0.1	3.4	0.7	0.4
OC	%	2.1	24.8	11.9	3.7
C:N	value	2.0	87.0	22.3	13.5
Exch.Ca	cmolkg^{-1} of compost	0.8	18.5	7.8	4.0
Exch.Mg	cmolkg^{-1} of compost	1.0	11.4	6.5	2.2
Av. P	mgkg^{-1} of compost	0.9	52.5	31.1	11.3
Mn	mgkg^{-1} of compost	11.2	304.2	88.0	47.3
Fe	mgkg^{-1} of compost	3.3	186.4	68.1	43.1
Cu	mgkg^{-1} of compost	0.9	10.3	3.4	1.6
Zn	mgkg^{-1} of compost	1.7	42.3	12.5	7.0

Ec = Electric conductivity, TN = Total Nitrogen, Ex.Ca = Exchangeable calcium, Ex.Mg = Exchangeable Magnesium, OC = Organic Carbon, Mn = Manganese, Fe = Iron, Cu = Copper and Zn stands for Zink.

4. Conclusion and Recommendations

In sustainable and integrated crop production systems the inclusion of compost proved to have significant effect on quality and health of soil, and quantity and quality of crop production. Assessment was initiated with objectives to assess and evaluate nutrient contents of composts prepared from diversified material sources and to identify the gap for composting processes. In general 213 compost samples were collected from three districts in Buno Bedele Zone. For each compost sample 14 parameters 101 were analyzed according to the standard laboratory procedures. The majority of the parameters analyzed values included calcium, total nitrogen, carbon to nitrogen ratio (C: N), organic matter and moisture contents were below the standard ranges set by different literatures. These results might be due to unbalanced substrates used by farmers during compost preparation. Based on these analysis results, it can be concluded that all prepared composts by farmers were not fulfilled standard quality that could be due to lack of follow up of standard procedures required from raw materials combination to compost management. Therefore, to upgrade quality of farmers' prepared composts, it requires training of farmers and cloth supervision by agricultural experts and development agents during compost preparation process by farmers.

Acknowledgements

The authors would like to acknowledge Oromia Agricultural Research Institute for financial, logistic and material support during the assessment; highly indebted to all researchers, laboratory technicians and support staff of Bedele Agricultural Research Center for providing the necessary attention and follow up to make the assessment successful.

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