

Research Article

Assessing Selected Nutrient Content and Quality of Conventional Composts for Crop Production in Western Oromia, Ethiopia

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Abstract

One of the main reasons for poor soil fertility status of acidic soils is low content of soil available plant nutrients like N, P, S, exchangeable Ca and Mg and toxicity of Al and Fe resulted from low soil pH value. Amendment of acidic soil using organic sources like compost is very crucial for improving the livelihood of the society through increasing crop productivity. Therefore, this study was conducted to assess the nutrient content and quality of compost prepared at farmers' level and guiding the integrated use of both chemical and organic fertilizers approach sustainably. The compost samples were collected from seven districts, namely Guto-Gida, Sassiga, Guduru, Horo, Jima-Genet, Hawa-Gelan and Nedjo, in western Oromia Regional State. The composts were prepared at farmers' level from the locally available composting materials. The composting materials used were more or less similar in all districts except it might vary in one or two sources which were used at very low ratio compared to the main sources. The result of the compost nutrient content revealed that the mean values of EC, pH, TN and C:N ratio ranged from 1.22 to 1.99 mmhos/cm, 7.25 to 8.20, 0.45 to 0.74% and 11.51 to 12.65, respectively which fell within the acceptable range for good quality compost. On the other hand, the mean values of OC, available P, exchangeable Ca and Mg were ranged from 5.19 to 7.83%, 0.006 to 0.013%, 44.79 to 83.72 mg kg soil⁻¹ and 1.40 to 8.61 mg kg compost⁻¹, respectively which fell below the acceptable range for good quality compost. Based on the crucial parameters indicating good quality compost like pH and C:N ratio the compost prepared from the locally available composting materials by the farmers were for improving the overall quality of the soil. Hence, productivity of crops would increased by using compost as source of organic fertilizers from which farmers in the study area benefited sustainably.

Keywords

Compost, Quality Compost, Acceptable Range, Locally Available, Organic Fertilizer

1. Introduction

Crop productivity improvements in a sustainable way can be challenging in sub-Saharan countries including Ethiopia due to severe soil loss and imbalanced nutrients caused by soil degradation [1]. Removal of crop residues and continuous

cultivation of lands with low nutrient replenishment results in depletion of soil nutrients. It is obvious that application of chemical fertilizers satisfy the nutrient need of crops. However, in the present scenario, the non-judicious use of chem-

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ical fertilizers is posing both economic and ecological problems, particularly in developing countries [2]. On the other hand, sole application of organic inputs is constrained by low concentration of nutrients, time needed for their mineralization to release nutrients for plant uptake, high labor demand for preparation and transporting [3]. The up-to-date crop production systems require the execution of more efficient, sustainable, economical and locally sound management practices [4]. This can be achieved by supplemental use of organic inputs together with mineral fertilizers [5]. Crop productivity of marginally fertile acidic soils can be improved through integrated use of soil ameliorants and fertilizers [6]. In sustainable crop production approaches, the insertion of organic sources like compost provides noteworthy outcome on amount and superiority of nutrients for crop productivity improvements [7, 8]. Addition of organic inputs to agricultural lands have multiple advantages like improving soil structure, slow and steady release of nutrients, reduce nutrient losses, increase water retention, boosts plant growth, reduce environmental pollution and enhanced plant resistance to pests and diseases; and finally increases crop yields [9]. The nutrient content and quality of conventional composts can vary based on the materials used, degree of decomposition, moisture content, nutrient content and contaminants (organic and non-organic materials or heavy metals). Compost equipped from a large amount of green organic inputs that is prosperous in nitrogen will increase acidity (low pH) of the compost, which might raise the sum acidity of the soil after use as amendment [10]. The process of composting requires the knowledge of C:N ratio to correctly mix up a desirable fraction of organic materials in the compost pile [11]. It is very imperative to maintain the C:N of the compost pile below 25:1. When the C:N ratio elevated or subordinate the composting process will be slowed down or can be congested at all [12]. Higher C:N would lesser duplication of decomposing microorganisms due to deficiency of N to synthesis their body protein while lower C:N result in high quantity of ammonia by microorganisms, which also cause lower pH, reduced breakdown and unpleasant odor of the compost [6]. Composting is a method of enhancing natural decomposition process, through that should be supplied with to intensify the activity of decomposing microorganisms. On the other hand, balanced carbon to nitrogen ratio (C:N) of raw organic materials, supplied with adequate moisture and oxygen and materials that have elements like Ca will produce in neutral to alkaline compost (high pH), which might lessen top soil acidity [11, 13]. It is not the amount of compost that applied to the soil, rather the amount of nutrients contained in that compost that determines the soil fertility thereby crop productivity. Due to this, laboratory quantification of compost nutrient content is pre-requisite for applying

compost to field. Farmers in Ethiopia are aware of the benefits that could be obtained from use of composts; however, the nutrient contents of conventional composts used by the farmers are not known; and data on nutrient content of these composts in the study area are scarce. Thus, characterizing the nutrient content of compost of prepared from different materials at farmers' level is very crucial. Therefore, the study was initiated with the objective to assess and evaluate the nutrient composition of conventional composts prepared by farmers from locally available materials in the study areas.

2. Materials and Methods

2.1. Descriptions of the Study Areas

An assessment was done across seven districts encompassing four zones in Western Oromia Regional State, namely, Guto-Gida and Sassiga districts in east wollega zone, Nedjo district in west wollega zone, Hawa-Gelan district in Kellem Wollega zone, and Jima-Genet, Horo and Guduru districts in HoroGuduruWollega zone (Figure 1). Guto-Gida lies between 8°57' to 9°30' N and 36°26' to 36°44' E with an altitude ranging from 1,350 to 2,450 meters above sea level. Sassiga lies between 8°50' to 9°20' N and 36°20' to 36°50' E with an altitude ranging from 1500 to 2000 meters above sea level. Nedjo lies between 9°30' to 9°55' N and 35°30' to 35°55' E with an altitude ranging 1500-2500 meters above sea level. Hawa-Gelan lies between 8°18' to 8°58' N and 35°12' to 35°55' E with an altitude ranging from 1,435 to 1,704 meters above mean sea level. Jima-Genet lies between 9°18' to 9°33' N and 37°06' to 37°07' E with an altitude ranging from 2,316 meters to over 3,053. Horo lies between 9°18' to 9°50' N and 37°00' to 37°20' E with an altitude ranging from 500 to 3,300 meters above sea level and Guduru lies between 9°10' to 9°50' N and 36°00' to 37°50' E with an altitude ranging from 880 to 2,430 meter above sea level. The average monthly temperature ranges between 11.9 to 29.9 °C, 10.35 to 28.22 °C, 11.56 to 29.25 °C, 11.75 to 28.45 °C, 11.80 to 28.55 °C, 12.05 to 27.55 °C and 10.75 to 29.15 °C for Guto-Gida, Sassiga, Nedjo, Hawa-Gelan, Jima-Genet, Horo and Guduru districts, respectively. The mean annual rainfall varies from 1,200 to 1,800 mm for Guto-Gida, from 816 to 1240 mm for Sassiga, from 750 to 1150 for Nedjo, from 500 to 950 mm for Hawa-Galan, from 1,880 to 2,080 mm for Jima-Genet, from 1,200 mm to 2,700 mm for Horo and from 1000 to 2400 mm for the above mentioned districts respectively. The economic activities of the local society in the study areas are primarily mixed farming system encompassing crop production and rearing of animals.

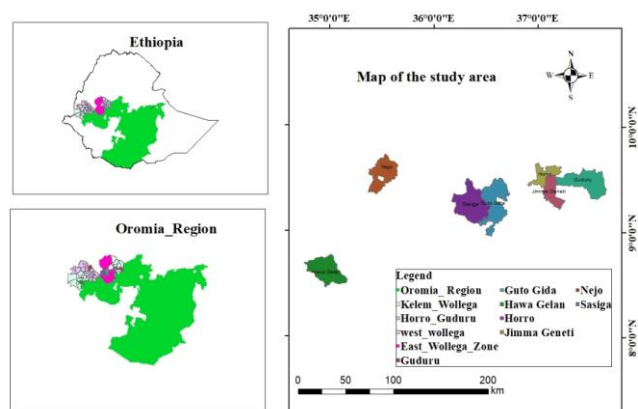


Figure 1. Map of the study area.

2.2. Selection of Districts and Farmers

Selection of districts from each zone and selection of farmers from each district were made purposively based on the experiences they have in preparing and management of conventional compost so far; willingness and accessibility to the road with the help of districts' agricultural experts and development agents.

Table 1. Common composting materials used.

Zone	District	Materials used	Remark
East Wollega	Guto-Gida	Fresh cow dung, top soil, ash and maize stalk	
	Sassiga	Fresh cow dung, topsoil, ash, maize stalk and leaves of pumpkin,	
	Guduru	Fresh cow dung, topsoil, ash, maize stalk and different weed species	
Horo-Guduru Wollega	Horro	Fresh cow dung, topsoil, ash and maize stalk	
	Ji-ma-Genet	Fresh cow dung, top soil, ash, maize stalk and different weed species	
Kellam Wollega	Ha-wa-Gelan	Fresh cow dung, topsoil, ash, maize stalk and leaves of pumpkin	
West Wollega	Nedjo	Fresh cow dung, topsoil, ash, maize stalk and different weeds species	

2.3. Composting

The process of composting was accomplished using pit method; the dominant composting technique used widely. The size of the pit was uniform as advised by development agents

which was 3 m*1 m*1.5 m for length, height and width, respectively. The composting materials used in each compost pit were more or less similar which were identified through interviewing. The main composting materials used in most of the observed sites were top soil, fresh cow manure, crop residues, weeds, plant leaves, ash, and leftover vegetables. The maize stalks were arranged horizontally in the pit which used as bedding. Each composting materials were chopped using sharp knife to increase surface area. First, topsoil was added on bedded maize stalk followed by plant materials then fresh cow dung and ash. In this order the arrangement of composting materials continued till the pit fulfill. At the end topsoil was used to cover composting materials. Within one month interval the composting materials were turned up manually where the lower bottom layers arranged at the upper layer and vice versa to have uniform maturity time and to get homogeneously mixed composting materials. The process of composting was done for the duration of four months.

2.4. Compost Sampling

The compost pile was mixed thoroughly before taking the sample. About fifteen small subsamples were taken from each pile considering from the upper, middle and lower part using stainless shovel. All the subsamples were again mixed thoroughly on a clean plastic tray, debris were removed and nearly about one kg was put in a labeled plastic bag and taken to laboratory for analysis. The number of compost pile selected from each district varies based on the physical quality the compost (maturity and odor) and the management done to handle the compost (free of contaminations like bird drop and plastics and storage place to avoid nutrient loss through sunlight or leaching, and etc). So, compost quality is the consequence of suspicious executive all through the production sequence, from gathering of the feedstock to storage space and appliance of the ultimate product.

2.5. Compost Sample Preparation for Analysis

The samples were allowed to air drying in room temperature, crushed using a mortar and pestle and sieved through a 2 mm mesh sieve. The chemical property of the compost was carried out following the standard laboratory procedure at Nekemte Soil Research Center. The pH of the compost was analyzed potentiometrically with a digital pH meter in the supernatant suspension of 1:5 (compost: water). Organic carbon (OC) content was determined by the dichromate oxidation method. Organic matter (OM) content was estimated from the organic carbon content by multiplying the latter by 1.724. Total N (TN) was estimated from the percent of organic matter. Available P was analyzed calorimetrically using ascorbic acid as a reducing reagent and its concentration was measured using spectrophotometer. Both the macro (Ca, and Mg) elements were extracted using di-ethylene tri-aminepentaacetic acid (DTPA) and their contents were

determined using atomic absorption spectrophotometer (AAS).

3. Results and Discussion

The results of the chemical property of the composts were presented in Table 2 below.

Electrical conductivity

The minimum and maximum electrical conductivity (EC) of the compost samples ranged from 0.29 to 3.99 with mean value 1.22 for Guto-Gida, from 0.06 to 6.33 with mean value 1.73 for Sassiga, from 0.76 to 7.07 with mean value 1.92 for Guduru, from 0.9 to 9.0 with mean value 1.6 for Horo, from 0.73 to 3.69 with mean value of 1.65 for Jima-Genet, from 0.29 to 8.49 with mean value 1.99 for Hawa-Galan, and from 0.34 to 6.03 with mean value of 1.86 for Nedjo. From this data it can be observed that the mean value for each district approaches to the minimum value than to the maximum value indicating the EC of many of the compost samples approaches to the minimum value. For all districts, the mean values of EC of the composts were found below the optimum range (<6 mmhos/cm) suitable for crop production [14]. Therefore, in relation with its salinity content, the compost of the study area prepared by farmers from the locally available composting materials is suitable for crop production. On the other hand, EC values higher than the optimum level can be harmful to germinating seeds and plants, finally affecting yield.

Compost Reaction (pH)

pH refers to the acidity/alkalinity of the materials. The results of the analysis revealed that the minimum and maximum value of the compost pH ranged from 6.50 to 8.78 with mean value 7.63 for Guto-Gida, from 5.99 to 8.55 with mean value 7.53 for Sassiga, from 6.65 to 9.19 with mean value 8.04 for Guduru, from 8.75 to 9.00 with mean value 7.25 for Horo, from 6.39 to 9.18 with mean value 7.90 for Jima-Genet, from 5.73 to 9.15 with mean value 7.90 and from 6.45 to 9.69 with mean value 8.20 for Nedjo. It was observed that the mean pH value of composts ranged from 7.25 to 8.04 which fall within the ideal range for crop production. The ideal pH value of compost which is suitable for crop production would range from neutral to slightly alkaline (5.0 to 8.5) which can be slightly varied based on the composting materials used [14]. Compost pH values below and above these range will affect its growth and yield. High pH value composts should not be accepted as it can lead to loss of N as NH_3 coupled with bad odor and compost pH value below 5.0 leads to hampering of bacterial and fungi growth [15]. The pH of finished compost near neutral to slightly alkaline due to the release of humus like substances with buffering capacity [16]; When compost is added to acidic soils, it increases the soil pH as a result of quick proton replace between the soil and organic amendments [17]. Hence, based on the mean pH values obtained, all composts prepared in all districts matches better for crop production, and the materials and composting process followed can be accepted to obtain good compost quality.

Organic carbon

The laboratory analysis result showed that percent organic carbon (%OC) content of the conventional compost ranged from 3.81 to 13.37 with mean value 7.83 for Guto-Gida, ranged from 3.12 to 15.45 with mean value 7.17 for Sassiga, ranged from 4.65 to 9.17 with mean value 6.79 for Guduru, ranged from 9.0 to 12.9 with mean value 5.58 for Horo, ranged from 4.95 to 12.06 with mean value 7.25 for Jima-Genet, ranged from 2.86 to 8.37 with mean value 5.19 for Hawa-Galan and ranged from 3.41 to 12.79 with mean value 6.38 for Nedjo districts. From the mean valuedata observed the OC of all the composts prepared at farmers level can be grouped inthe acceptable range for soil amendments and crop production [14]. When organic fertilizers like compost added to agricultural land, it reduces the greenhouse gas (GHG) emission due to the soils' storage capability of the soil carbon [18]. However, the magnitude of GHG sequestrations caused by the addition of composts varies based of the quality of the compost. In the developed countries, GHG adsorption is due to the sink of C as a result of organic amendments [19].

Total nitrogen

The total nitrogen percent (%TN) available in composts prepared at farmers level ranged from 0.33 to 1.15 with mean value 0.67 for Guto-Gida, ranged from 0.27 to 1.23 with mean value 0.62 for Sassiga, ranged from 0.30 to 1.03 with mean value 0.59 for Guduru, ranged from 1.04 to 9.0 with mean value 0.74 for Horo, ranged from 0.43 to 1.09 with mean value 0.63 for Jima-Genet, ranged from 0.25 to 0.72 with mean value 0.45 for Hawa-Galan and ranged from 0.29 to 1.10 with mean value 0.55 for Nedjo districts. According to [20] quality compost consisted of TN content ranged from 0.45 to 3.50%; and all the mean values compost samples fell within this range which could happened due N available in the initial composting materials and the recycling of N from dead microorganisms during decomposition. This suggested that the on average the locally available composting materials used, the composting procedures followed and the handling done during composting resulted in the production of good compost quality.

Carbon-to-nitrogen ratio

The often used parameter in determining the rate of decomposition of compost is the carbon-to-nitrogen ratio (C:N ratio) which indicates the maturity and quality of the compost. The mean C:N values of composts prepared at farmers level ranged from 11.51 to 12.65 for all districts which grouped under the intended category according to [14]. According to this author the optimum level for C:N ratio of mature compost for complete decomposition ranged from 10 to 25. On the other hand, a C:N ratio below 20 is an acceptable level for complete decomposition of composts as stated by [21]. Many organic soil amendments seldom meet the acceptable completely matured C:N ratio range [21]. However, many feed stalks fixed to achieve this range as much as possible. A lower C:N ratio creates an intense ammonium odor with significant losses of N leading to limited growth microorganisms

while a higher C:N ratio may immobilizes N in the soil causing plant stunting and C is not in the available forms [22]. Therefore, the C:N ratio of composts prepared at farmers' level fell within the acceptable range of completely matured compost and it can be used as soil amendments.

Available phosphorus

The mean phosphorus content of compost samples collected from Guto-Gida, Sassiga, Guduru, Horro, Jimma-Genet and Hawa-Gelandistricts were 0.01, 0.006, 0.008, 0.008, 0.01 and 0.013% while the minimum and maximum value ranged from 0.005 to 0.014, from 0.001 to 0.014, from 0.004 to 0.013, from 0.001 to 0.011, from 0.006 to 0.015 and from 0.004 to 0.016%, respectively, for the above districts. The mean percent P values of compost samples for all districts fell below the acceptable range which is 0.2 to 3.0% according to [14]. This might be due to the low P content of feed stalks used. This result is similar to the findings of other scholars who reported that low availability of P in the finished compost which might be due to the leaching of P in the soluble organic solute [23]. When compost added to acidic soils, it increases the soils' pH value which in other way create suitable condition for the availability of plant nutrients like P and Ca and bioavailability of labile P for the long period of time while reducing the toxicity of other elements like Al and Fe [24].

From this it can be concluded that although the composts prepared at farmers' level have low P content after their final maturity, it can be suitable as soil amendments as it increases soil pH at which the availability of other plant nutrients and soil microbes increased.

Calcium(Ca) and Magnesium (Mg)

The Ca and Mg content of composts prepared at farmers level ranged from 44.79 to 83.72 mg kg soil⁻¹ and ranged from 1.40 to 8.61 mg kg compost⁻¹, respectively. The acceptable range of Ca and Mg values of completely matured compost ranged from 15,000 to 35,00 and ranged from 2,500 to 7,500 mg kg compost⁻¹, respectively [25]. Although the Ca and Mg content of composts fell below the acceptable range, amending an agricultural land with organic compost leading to an improvement in the physical, chemical and biological properties of soil due to the increased in soil pH as a consequence of compost addition [26]. The improvements in the physical (like aeration, water and nutrient holding capacity), chemical (like soil reaction) and biological (like bacteria and fungi) properties of an agricultural soils leading to the availability of the inherently existing plant nutrients and the efficiently utilization of the externally added chemical fertilizers.

Table 2. Descriptive statistical values for composts' selected chemical properties.

Descriptive Statics	District						
	Guto-Gida	Sassiga	Guduru	Horo	Jimma-Genet	Hawa-Gelan	Nedjo
Composts' Electrical conductivity (mmhos/cm)							
N	27	24	16	9	10	19	41
Mean	1.12	1.73	1.92	1.40	1.65	1.99	1.86
Minimum	0.29	0.06	0.68	3.90	0.73	0.29	0.34
Maximum	3.99	6.33	7.07	9.00	3.69	8.49	6.03
pH(1:2.5H ₂ O)							
Mean	7.63	7.53	8.04	7.25	7.90	7.90	8.21
Minimum	6.50	5.95	6.65	8.75	6.39	5.73	6.45
Maximum	8.78	8.55	9.19	9.00	9.18	9.15	9.69
P (mg kg ⁻¹)							
Mean	92.29	60.14	84.79	73.74	99.86	130.96	NV
Minimum	50.22	12.30	40.86	110.41	58.81	41.14	NV
Maximum	136.52	137.82	132.05	9.00	146.08	156.55	NV
OC (%)							
Mean	7.83	7.17	6.79	8.58	7.25	5.19	6.38
Minimum	3.81	3.12	4.65	12.09	4.95	2.86	3.41
Maximum	13.37	15.45	9.17	9.00	12.60	8.37	12.79

Descriptive Statics	District						
	Guto-Gida	Sassiga	Guduru	Horo	Jimma-Genet	Hawa-Gelan	Nedjo
TN(%)							
Mean	0.67	0.62	0.59	0.74	0.63	0.45	0.55
Minimum	0.33	0.27	0.13	1.04	0.43	0.25	0.29
Maximum	1.15	1.33	0.27	0.40	1.09	0.72	1..03
C:N ratio							
Mean	11.69	11.56	11.51	11.59	11.51	11.53	11.60
Maximum	11.63	11.62	33.96	22.5	11.60	11.63	12.42
Minimum	11.55	11.56	35.76	11.63	11.52	11.44	11.58
Ca (mg kg ⁻¹)							
Mean	79.99	71.88	83.72	47.87	44.79	61.00	NV
Minimum	39.13	21.41	8.60	78.99	18.26	41.86	NV
Maximum	115.69	127.44	151.91	9.00	85.56	95.43	NV
Mg (mg kg ⁻¹)							
Mean	8.56	8.61	7.00	1.40	5.60	8.44	NV
Minimum	3.72	2.61	0.89	3.90	1.56	6.11	NV
Maximum	14.50	13.50	12.78	9.00	12.11	12.16	NV

NV= No value

as soil amendments in maximizing the productivity of crops.

4. Summary and Conclusion

The result of the laboratory analysis revealed that due to diverse maturity status composting process, the quality of available compost can vary widely. Compost testing is pre-requisite for applying compost to agricultural field. The main parameter of compost determining the finished maturity status and quality of compost; the C:N ratio; fell with the acceptable range which indicate the suitability/quality of the compost as soil amendment. Similarly, the EC (< 6 mmhos/cm), pH (neutral to slightly alkaline) and total %N (0.45 to 3.50%) of the compost prepared at farmers' level from the locally available materials fell within the acceptable range. On the other hand, the %OC, available P, exchangeable Ca and Mg fell below the acceptable range indicating the low content of the initially used feed stalks for composting. It was concluded that the compost prepared at farmers level used to enrich the soil with organic matter content leads to have resilient and health plants as a result of enhanced overall soil quality. Thus, the farmers would likely be encouraged and advised to shift from only using chemical fertilizers to integrated application of both chemical and organic fertilizers to have a health soil and plants. Therefore, farmers from the study area can benefit by using the locally prepared compost

Abbreviations

AAS	Atomic Absorption Spectrophotometer
Al	Aluminum
Ca	Calcium
C:N	Carbon to Nitrogen ratio
DTPA	Diethylene triaminepenytaacetic acid
EC	Electrical Conductivity
Fe	Iron
GHG	Green House Gas
Mg	Magnesium
OC	Organic CarboN
OM	Organic Matter
P	Phosphorus
S	Sulfur
TN	Total Nitrogen

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Conflicts of Interest

The authors declare no conflicts of interest.

References

- [1] Gashaw T, Bantider A, Gebresilassie H. Land degradation in Ethiopia: Causes, impacts and rehabilitation techniques. *Journal of Environmental Earth and Sciences*, 2014; 4(9): 98-104.
- [2] Sutton M, Howard C, Erismann J, Billen J, Bleeker A, Grizzetti B. The European nitrogen assessment, sources, effects and policy perspectives. 2011.
- [3] Agegnehu G, van-Beek C. Bird M. Influence of integrated soil fertility management in wheat and tef productivity and soil chemical properties in the highland tropical environment. *Journal of Soil Science and Plant Nutrition*, 2014; 532-545. <http://dx.doi.org/10.4067/S0718-95162014005000042>.
- [4] Fageria N, Baligar V. Ameliorating soil acidity of tropical Oxisols by liming for sustainable crop production. *Advances in Agronomy*, 2008; 99:345-399. [https://doi.org/10.1016/S0065-2113\(08\)00407-0](https://doi.org/10.1016/S0065-2113(08)00407-0)
- [5] IFPRI (International Food Policy Research Institute). Fertilizer and soil fertility potential in Ethiopia, Constraints and opportunities for enhancing the system, working paper. 2010. <https://doi.org/10.13140/RG.2.1.3632.5846>
- [6] Văghe P, Bationo A, Waswa B, Kihara J, Kimetu J (eds.). Advances in integrated soil fertility management in Sub-Saharan Africa: Challenges and opportunities. Springer, Netherland. 2007. <https://library.au.int/fradvances-integrated-soil-fertility-management-sub-saharan-africa-challenges-and-opportunities>
- [7] Ganjali H, Mobasser H, Esmailzadeh A, Tavassoli A. Effect of organic compost on yield and protein content of corn cultivars in Khash region. *Journal of Novel Applied Sciences*, 2013; 2: 369-374.
- [8] Sreenivas C, Muralidhar G, Rao M. Vermicomposts: a viable component of IPNSS in nitrogen nutrition of ridge gourd. *Annals of Agricultural Research*, 2000; 21(1): 108-113. <https://www.researchgate.net/publication/259474911>
- [9] Amlinger F, Peyr S, Geszti J, Dreher P, Weinfurter K, et al. Beneficial effects of compost application on fertility and productivity of soils. Federal Ministry for Agriculture and Forestry, Environment and Water Management, Austria. 2007.
- [10] Rader H. The compost heap: Basic composting in Alaska. University of Alaska Fairbanks, Alaska. 2013.
- [11] Chen L, Marti M, Moore A, Falen C. The composting process: Dairy compost production and use in Idaho. 2011.
- [12] Christian A, Evanylo G, Pease J. On-farm composting: A guide to principles, planning and operations. Virginia Cooperative Extension, VirginiaTech, Virginia State University, Petersburg. 2009.
- [13] TMECC (Test Methods for the Examination of Composting and Compost). A manual: a collaborative effort by the United State Department of Agriculture (USDA) and the United State Composting Council (USCC) 2001a. <https://compostingcouncil.org/tmecc/> (verified 17 Aug 2018).
- [14] Gajalakshmi S, Abbasi S. Solid waste management by composting: state of the art, *Crit. Reviews in Environmental Sciences and Technology*, 2008; 38: 311-400, <https://doi.org/10.1080/10643380701413633>
- [15] El Fels L, Zamama M, Asli A., Hafidi M. Assessment of bio-transformation of organic matter during co-composting of sewage sludge-ligno-celulosic waste by chemical, FTIR analyses, and phytotoxicity tests. *International Bio-deterioration and Biodegradation*, 2014; 87:128-137. <https://doi.org/10.1016/j.ibiod.2013.09.024>
- [16] Ozkaraova G, Bekb ölet M. Zinc release by humic and fulvic acid as influenced by pH, complexation and DOC sorption, *Geoderma*, 2010; 159:131-138, <https://doi.org/10.1016/j.geoderma.2010.07.004>
- [17] Sage Publications, Compost Can Turn Agricultural Soil into Carbon Sink. Thus Protecting against Climate Change. *ScienceDaily ScienceDaily*, 27 February, 2008. www.sciencedaily.com/releases/2008/02/080225072624.htm
- [18] Razza F, D'Avino L, Abate G, Lazzeri L. Designing sustainable technologies, *Prod. Pol.* 2018; 133-143, <https://doi.org/10.1007/978-3-319-6698-6-16>
- [19] Rasapoor M, Nasrabadi T, Kamali M, Hoveidi H. Waste Management. 2009; 29(2): 570-573.
- [20] Jusoh M. L. C, Manaf L. A, Latiff P. A. Composting of Rice Straw with Effective Microorganisms (EM) and Its Influence on Compost Quality. *Iranian Journal of Environmental Health Science and Engineering*, 2013; 10(1): 1-9. <https://doi.org/10.1186/1735-2746-10-17>
- [21] Huang G. F, Wong J. W, Wu Q. T, Nagar B. B. Effect of C/N on composting of pig manure with sawdust, *Waste Management*, 2004; 24: 805-813. <https://doi.org/10.1016/j.wasman.2004.03.011>
- [22] Makan A, Assobhei O, Mountadar M. Effect of initial moisture content on the in-vessel composting under air pressure of organic fraction of municipal solid waste in morocco. *Iranian Journal of Environmental Health*, 2012; 10: 3. <https://doi.org/10.1186/1735-2746-10-3>
- [23] Ch'ng H. Y, Ahmed O. H., Majid N. M. A. Improving phosphorus availability in an acid soil using organic amendments produced from agro-industrial wastes, *Scientific World Journal*; 2014. <https://doi.org/10.1155/2014/506356>
- [24] Tumuhairwe JB, Tenywa JS, Otabbong E, Ledin S. Comparison of four low-technology composting methods for market crop waste. *Waste Management*, 2009; 29: 2274-2281. <https://doi.org/10.1016/j.wasman.2009.03.015>
- [25] Miller R. O. Compost Analysis Proficiency Program. Sample ID: SRC-2015-D (110, 111, 112). 2018.

- [26] Medina J, Monreal C, Barea J. M, Arriagada C, Borie F, Cornejo P. Crop residue stabilization and application to agricultural and degraded soils: A review, *Waste Management*, 2015; 42: 41-54.
<https://doi.org/10.1016/j.wasman.2015.04.002>