Evaluate The Produced Compost and Vermicompost Locally, According to Some Physical, Chemical, and Biological Standards of The Compost

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Abstract

This study was conducted during the period (25 August 2024-25 August 2025) in the labs of the Soil and Water Sciences Department, College of Agricultural Engineering Sciences, University of Duhok, to evaluate compost and vermicompost produced from farmyard residues and sheep manure via aerobic (hot) composting and vermicomposting techniques. Many individual samples were collected from different sites of their piles, each of them separately, then mixed well, and a composite sample was made from each of them following the scientific standard methods, and after that, they were stored in the sterilized plastic containers in the refrigerator at 4°C till analyzing. The studied composts were analyzed and tested for some physical parameters (color, odor, moisture content (%), maximum water holding capacity (%), bulk density (g cm^{-3}), and porosity (%) and chemical parameters [pH, EC (dSm^{-1}), cation exchange capacity (Cmolc kg^{-1}), ash content (%), N, P, K (%), C/N ratio, OC %, OM %, lead (Pb), cadmium (Cd), and chromium (Cr) mg kg^{-1}], as well as biologically tested for total bacteria, total yeast and mold, total coliform, and fecal coliform (E. coli). Generally, the results indicated that the investigated compost, depending on some studied physical, chemical, and biological properties of the compost quality standards, has not reached the final stage of stability and maturity. As well as biologically, it is contaminated with the fecal bacteria of E. coli. While the quality of the studied vermicompost was superior to that of compost in most studied physical, chemical, and biological parameters, which indicates that it has reached the stability and maturity stage, it was also free from pathogens such as fecal bacteria (E. coli). The vermicompost was classified as class-A compost according to the European Specification Standards of the compost.

Key words: Compost, vermicompost, physical, chemical and biological parameters of compost and Heavy metals.

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Introduction

A massive amount of organic soild waste (OSW) is produced over the entire world, which account about (2.01 billion metric tons), and it is expected to increase to (3.40 billion metric tons) by 2050 [5,15,33] Reported that these massive amounts of organic solid waste from human activities, if not remediated well, will lead to environmental pollution problems that threaten the natural resources and human health risks. This encouraged the researchers all over the entire world to meet this challenge and to face this big problem to be solved by finding out new environmentally safe strategies for managing to get rid of these wastes and converting them into a beneficial organic fertilizer (OF) to be used in fertilization by the farmers, to contribute to improving the soil health, including soil fertility, and to increase crop productivity with good quality. [20] mentioned that composting of the OSW and converting it to stabilized organic waste known as compost (humus), which is rich in essential elements for plants, is quite a significant technique for preventing, reducing, and preserving the environment from contamination. However, vermicomposting is a biological process for composting that aerobically decomposes and stabilizes organic waste by the action of earthworms and microbes in their gut, producing a beneficial vermicompost or vermicast rich in essential nutrients for plants. While [21] indicated that compost is produced through a composting process by the soil organisms, which decompose OSW aerobically and thermophilically. While vermicompost results from the action of both earthworms and microorganisms in their guts, also aerobically, producing a final benefical compost known as vermicast or vermicompost. When [47] demonstrated that in spite of the significant benefits of land fertilization with compost and vermicompost for improving the soil properties and enhancing plant production, it also has drawbacks to be concerned about because it may still contain such toxic heavy metals [e.g., lead (Pb), cadmium (Cd), and chromium (Cr)] that are absorbed by plants and accumulated in their edible parts, finally enter the food chain and then the human bodies. [48] reported that the consecutive accumulation of heavy metal in the environment and its uptake by plants, then the human body, through the food chain will cause problems of environmental pollution and human health concerns.

One of the priorities for ensuring safe and effective use of the compost before using it in farming is to evaluate its quality for immaturity and contamination with toxic compounds and heavy metals that adversely influence plant growth, production, soil properties, and soil organism activity. Many researcher in kuristan region –Iraq have been assessed the quality of some imported and locally produced compost such as, [29,30,13,12,8,4]. But no one have been studied this produced compost locally, therefore this study came to evaluate these composed and vermicompost the aim of this study to evaluate the produced compost and vermicompost at the department of Protected Cultivation at Technical Institute of Zakho/ Duhok Ploytechnique University. depending on same compost quality standards.

Material and methods

This study is a subset of an MSc project conducted during the period 25 August

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2024-25 August 2025 in the labs of the Soil and Water Sciences Department, College of Agricultural Engineering Sciences, University of Duhok, to evaluate the compost and vermicompost produced locally by the Protected Cultivation Department, Technical Institute of Zakho/Duhok Polytechnic University, the Kurdistan Region/Iraq, depending on some physical, chemical, and biological parameters and some international standards compost quality indices (Figure 1).

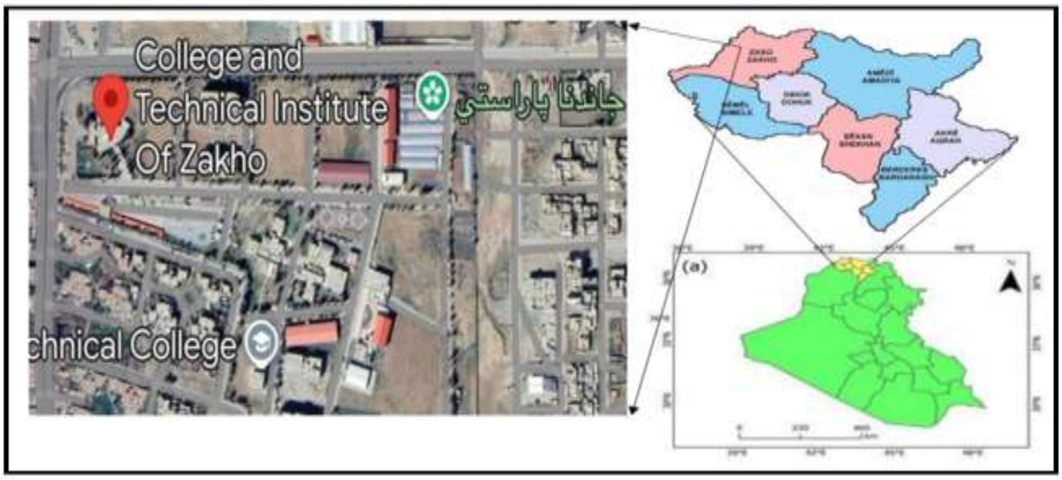

Figure (1): Shows the sites of the Technical Institute of Zakho/Duhok Polytechnic University on the map.

Compost and Vermicompost Laboratory Analysis (Physical, Chemical and Biological) Parameters.

In this study some of the physical, chemical and biological parameters that used in evaluating compost quality products were tested and analyzed for assessing both studied compost and vermicompost qualities. The color and odor of the fresh compost and vermicompost samples were assessed using the naked eye and sense of smell, respectively, [34], moisture content, [23], Maximum water holding capacity (MWHC) described by [6]. bulk density as mentioned by [40]. Porosity as described by [23]. The studied chemical parameters of both compost and vermicompost samples were pH value, electrical conductivity (EC) value or salinity were determined in (1:10) compost extracts at 25°C using bench top pH meter (Trans Instruments model BP3001), and bench top conductivity meter (Trans Instruments model BC3020), [46]. A flame photometer device, type

JENWAY model PFP7, was used to determine Na concentrations was determined in compost extracts calculating cation exchange capacity (CEC) of the composts, [43], while total Na and K were determined by the same flame photometer device in digested compost extractsas explained by [16]. The percentage of Ash content in the studied compost samples was determined by dry oxidation using a muffle furnace, type Lab TECH/LEF-115S, at 550°C, [16]. The same method used to measure total ash was also used to determine total organic carbon calculated as follows by [1]. For calculating the Total Organic Matter content (OM) % in the studied compost and vermicompost samples using the same procedure used for Total Organic Carbon measurement as mentioned by [1].A Kjeldahl method was depended on for the determination of the total N, and a colorimetric method for determination of the total phosphorous in the digested extracts of the studied composts using a spectrophotometer device, type JENWAY model 7000 UV-Vis, as mentioned by [46]. Regarding heavy metals (Pb, Cd, and Cr) concentration, were determined in the wet digested acid mixture of (nitric acid (HNO3), Perchloric acid (HClO4)] as mentioned by [24] and determined by using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) Thermo Fisher type**.** However, carbon to nitrogen ratio (C: N) was computed via dividing the total organic carbon by the total nitrogen content of the studied compost samples. The studied compost and vermicompost products were tested biologically for some important parameters to ensure the safety use compost products in agricultural farming. Therefore, the studied composts were tested for the total heterotrophic bacteria (THB), [10]. The most probable number (MPN) for estimating the total coliform bacteria. The same protocol and medium were used for inoculating the positive tubes of the total coliform bacteria for accounting Escherichia coli (E. coli) or fecal coliform, [41].

Results and desscusion

Evaluation the the studied compost and vermicompost

physical Parameters

Color and odor

The color and odor of the compost product are important physical parameters that determine the maturity and stability of the final compost product. Regarding the color of the compost and vermicomposte product they were blake and dark brown in color respectively (Table 1), which reflects the well degradation humification of raw organic materials and its stabilization, tthus the studied composts were reached the maturity. These results are agreed with those stated by [34], who reported that compost maturity refers to compost stability chemically and the homogenized friable humus-like texture, as well as the reduction in its C/N ratio, also,[15], stated that the dark color of the compost product is an evidence to well humification and the existence of the stable humic substances.

Relying on the oder of the compost, it was slightly nasty oder for the compost and oderless for the vermicompost (Table 1), which means that the curring time of compost product was not enough, or may be over moistend, or not mixed well for aeration which led to reslease ammonia, or H_2S gases,. The vermicompost was odorless comparing with the studied compost of slightly-nasty odor. Which is an evident that biological degradation action of organic materials by earthworms well performed, due to digestion OSW during their passage in the instentine which digeste under the action of digestive galnds as well as contribution of the

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associated microorganisms in their gutes and transform it to more stabilized vermicompost , as well as decreases formation the volatile compounds it that give odor, these results are agreed with those reportd by [38,25,34,15,36,7,3].

Moisture content

The water is deemed the most important medium for microbial activity, and it is a medium in which all chemical reactions occur [34]. The MWHC is a major physical indicator to what extent the compost will retains water. The moisture content and maximum water holding capacity (MWHC) in the studied compost and vermicompost were varied. The moisture content in the compost was 41.56%, and for vermicompost was 38.89% (Table 1). Thus, the moisture content in the studied composts falls between the suggested optimal range of compost standard (35–55)%, [28].

Table (1): Shows some of the physical analyses of the studied compost and vermicompost.

Studied Parameters	Units	Compost Values	Vermicompost Values
Color	-	Black	Dark brown
Oder	-	Slightly nasty Oder	Odorless
Moisture Content	%	41.56	38.89
Maximum Water Holding Capacity (MWHC)	%	112.23	98.64
Porosity	%	54.2	54.3
Bulk density (ρb)	g cm^{-3}	0.671	0.646

Maximum water holding capacity (MWHC)

While the MWHC was (112.23 and 98.64) % for the compost and vermicompost repectively (Table 1). These results are going with the values of the bulk density and porosity of the studied compost and vermicompost, which were (0.671 and 0.646) kg m^{-3} and 54.2% and 54.3%, respectively, which means that the compost with higher porosity will absorb and retain more water of that lower porosity and higher bulk density. The moisture conten in compost was slightly higher of the in vermicompost, which may refer to its larger particle size, which lead to retains more water in compairing with more fine particle size and stable aggregates of vermicompost, that retains slightly low water in spite of it is more active biologically. As well as the

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differences in moisture conten, MWHC, bulk densıty and

porocity of the studied composts may be attriuted to the type of the used feedstock, the final particle size of the compost products and composting techniques, this interperation are going with those stated by [34,44,35,7,27] reported that that vermicompost produced from cattle manure recorded lower moisture content of 37.6%, of the moisture content (44.2%), in the produced compost. Also,[59] ,mentioned that MWHC OF compost produces from plant scarps and animal manure may reach to have up to 120%, while its value in vermicompost usually located among (90–110)%, depending on the fedstock materials used in composting and technique of composting . The slightly low MWHC in vermicompost may refer to its more fine granular structure and low of undecomposed organic matter in it, which absorb more water.

Porosity

Although the porosity of studied comops and vermicompost were had a good porosity, while its value for vermicompost was slightley more in value of its value of compost this may attributed to the fine granular particle size of the vermicompost in compairing with the coarse particle size of the compost. [42], mentioned that the High value of porosity (>50%) of the compost is very necessary for air exchange with atmosphere, microorganisms respiration and decomposition of OSW, promotes nutrient cycling, water infiltration and movement. and enhances plant growth. These results are agreed with those stated by [35], who found that porosity value of the composts and vermicomposts made from OSW rnged between (50–60)%. Also, similar results were recorded by [4], when used vermicomposting technique in composting 50% of each of cow dung and wheat straw.

Bulk density (ρb)

While the bulk density (ρb) values of the studied of the composts and vermicompost were low (0.671 and 0.646) g cm^{-3} for both compost and vermicompost respectively (Table 1). Thses values are favorable which enhances aeration and improves soil air exhange with atmosphere for root development and microbial activity. [31]stated that the optimal value of bulk density for composts should be less than (0.8 g cm^{-3}) boosts the soil aeration, water infiltration , water movement and microbial activity.These results are similar to theose found by When, [11] who reported the bulk density of the compost made from agricultural byproducts and manure is reanged between (0.65–0.75) g cm^{-3}. while, [21] found that the ρb of the vermicompost was lower in comparision with ρb value of the compost. This is attributed to earthworm action and their movement that increases the vermicmpost porosity and aggregation. The low values of the ρb of the studied compost and vermicompost to ensure its suitability to use in compacted soils to improve their porosity. Depending on the porosity percentage of the studied composts and vermicompost were nearly similar which were (54.2and 54.3) % resprctively (Table 1).

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Chemical Parameters

Potential Of Hydrogen İons (PH)

While regarding the chemical parameters of compost products. The pH value of the compost is considered a very necessary chemical parameter in monitoring the process of composting because it influences organic solid waste (OSW) degradation by microbes [4,32] suggested that the pH value must not be too acidic or alkaline but should be between (6 and 8), for the best biodegradation of OSW. [57], stated it depends on the type of feedstock materials used in composting. The pH value of the studied compost was slightly acidic and close to neutral, with a pH value of 6.83, while for the vermicompost it was slightly to mid-alkaline, with a pH value of 7.38 (Table 2). These differences in the pH value of the studied composts are attributed to the differences in the feedstock type used and the degree of decomposition by worm action. [15] reported that the best pH for decomposing OSW by microorganisms ranges from neutral to slightly alkaline to release nutrients to be available to plants in soils. [21] stated that the pH value of the vermicompost tends to be higher than that of compost because the worms enhance OSW decomposition and nitrogenous compounds that release the exchangeable Ca^{2+} and Mg^{2+} cations that are alkali elements on the surface of the OSW and soil components into the soil solution. These results are consistent with [19,11] who reported that the optimal range of the pH values of the compost products is between 6.5 and 7.5), and 5.5 and 8.5 [40]. While the pH value for the vermicompost ranges between (7.0 and 7.8), [11].This supports the impact of the vermicompost in buffering the pH of the acidic soils.

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Table (2): Shows some of the chemical analyses of the studied compost and vermicompost.

Studied Parameters	Units	Compost Values	Vermicompost Values
pH in (1:10) extract	-	6.83	7.38
Electrical conductivity (EC) in (1:10) extract	($dS.\ m^{-1}$)	3.41	0.59
Cation exchange capacity (CEC)	$Cmol_c\ Kg^{-1}$	28.76	27.77
Ash content %	%	43	42.6
Total Organic Carbon (TOC)	%	31.66	31.88
Organic Carbon (OM)	%	57	57.4
Total Nitrogen (TN)	%	1.9	1.6
Carbon: Nitrogen Ratio (C/N)	%	16.66	19.92
Total Phosphorous (TP)	%	0.7	0.5
Total Potassium (TK^+)	%	0.46	0.35
Total Sodium (TNa^+)	%	0.44	0.26

Electrical Conductivity (EC)

The high EC value of the compost products influences plant root growth and damages them, causes nutrient imbalance due to the competition between nutrients in uptake by plants, and decreases the available water to plants [54,57] also affects seed germination via phytotoxicity, influences root and plant growth [26]. The EC value of the studied compost was moderately high with value 3.41 dS m^{-1} which means that it content relative high concentration of the dissolved salts, whereas, its concentration in the vermicompost product was much lower with EC value 0.59 dS m^{-1}, that means of low salinity risk. [59] demonstrated that high EC value of the compost product is a clear evident that the compost is not reach maturity stagem which can can restrict seed germination and plant growth especially in case using in high rates. whereas, [42] pointed that ingeneral the EC-values of lower than (4 dS m^{-1}) are alowable for cultivation of most cropsm if its application controlled. [35], stated that low EC-value of the studied vermicompost is an evidence of its higher stability and low phytotoxicity, who found the that EC-value of the vermicompost is decreased due to the microorganisms that lives in the intestine of worms and comsums the ions from the digestive materials during their passage in their gut. These results are agreed with those found by [4] and the optimal value suggested by [40].

Cation Exchange Capacity (CEC)

Table (2) shows that the cation exchange capacity (CEC) of the studied composts was slightly higher for the compost with 28.76 cmolc kg^{-1} than for the vermicompost with a value of 27.77 cmolc kg^{-1}. This indicates their high capacity to retain nutrients, enhances the soil buffering capacity, and prevents nutrients from being lost with drained water, thus improving the nutrient holding capacity and contributing to sustaining the soil fertility for the long term, especially in sandy texture soils. The reason for the high CEC of the studied composts may be referred to the high organic matter content in the compost and the type of the composted feedstock. These results agree with the findings of [31,4]

Ash Content

Ash content reflects the amount of the element fractions in the biodegradable composted organic solid wastes after oxidation. The ash content of the studied compost products was similar, their values were 43% and 42.6% for compost and vermicompost, respectively (Table 2). These results are supported by the fact that both residue materials used in composting are rich in minerals, with slightly more OM content (57.4%) in vermicompost in comparison with the compost (57%) (Table 2). This slight variatio attributed to the superior biological activity of worms and their greater potential ability to digest the OM and form humus. These results are going in accordance with the relationship between ash and organic matter content in both studied compost and vermicompost. These results are compatible with the optimal value stated by[40] of more than 30%. Similar results were reported by [7,4].

Total Organic Matter Content (TOM)

in the studied compost and vermicompost was (57 and 57.4)%, respectively (Table 2), with a minor higher amount in vermicomposting. This may be attributed to the types of the organic material and their ratios used in composting, which may originally vary in the carbon and nitrogen ratios. These results are aligned with the results of total organic carbon (TOC) and total nitrogen content (TN) in the final products of the studied compost and vermicompost. These results go with those reported by [46,7,3,4] who stated that the TOC, TOM, TN, and final C:N ratio of the compost products are influenced by the nature and C and N content in the decomposed OSW materials as well as by the composting technique and composting management process.

Total Organic Carbon (TOC)

The value of the total organic carbon (TOC) content of the study compost was 31.66% for the compost and 31.88% for the vermicompost (Table 2). Their values were very close in both studied compost products, showing high levels of stabilized organic carbon and assuring advanced decomposition and humification, which supports organic carbon retention in the soil for a long duration. These results are consistent with those stated by [27] who recorded the TOC values 30% and 34% for composts and vermicomposts, respectively. Also these results are compatible with values of the organıc matter contents of the studied composts which (31.66 and 31 88)% for compost and vermicompst respectively, (Table 2). Semilr results werereported by [7,4]. This results are compatiable with the total organic matter content in the sutdied composts.

Total Nitrogen (TN)

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The total Nitrogen (TN) content in the studied comost and vermicompost were 1.9% and 1.6% respectively (Table 2). The TN content in the vermicompost was less than of compost, and this may be explaned that the consummed OSW through vermicomposting it passess in their intesntines thus the nitrogen is absorbed by them, as well as N is consumpted by the microbes that lives in the guts, therefore th TN content inthe vermicompost product is less. Also, the reasone may be demonstrated that nitrogen losses during composting is low due mixing the compost piles for aeration occasionly, compared to vermicomposting, where ammonia volatilization may occur more actively [36]. According to [15] the studied compost and vericompost are classifies within high quality compost , because it content high amount of TN > 1.5%, which is a desirable to be use as an effective organic amendments ın sustaınable farmıng.

C:N ratio

From (Table 2), appear that the C:N ratio in the studied compist was 16.66, while in the vermicompost was 19.92 (Table 2). This means that the both staudied compost and vermicompost are stabilized compost materials according to [28,15] who stated that ideal C: N ratio in the compost products is ranged between (10:1 and 20:1), and and the compost product has a C: N ratios within this range, is considered aa a stablilzed compost. The compost product of low C:N ratio indicates to that the composted materials were decomposed to a higher degrees of mineralization, which in turn may lead to nitrogen mineralization rapiedly in soils. while the high C:N ratio in vermicompost indicates to it conten more stable carbon, which is favorable because it decompose step by step and act as a slow release fertilizers for nutrient, as well as it is good for increasing organic matter content in the soil. Also. [39], noted that the compost products with C: N ratio 20, is considered a mature compost and can be used as a organic fertilizer.This findings are going with those mentioned by [11] who stated that the composts with C: N ratio less than 20 is considered as suitable compost for organic farming and it dose not led to N losses through immobolization by the soil microbs. semilar results were rcorded by [7,3].

Total Phosphorous (TP) and Total Potassium (TK)

It appear from (Table 2) that the total phosphorous (TP) and total potassium (TK) in the studied compost were (0.7 and 0.46)%, higher of that in vermicompost with values (0.5 and 0.35)% respectively. Vermicompost content lower percentages of P and K, of that in compost. This indicated that the nutririent power-supply capability of the studied compost to the soil is higher of that vermicompost. Therefore, the compost can release more essential nutririents to soil with time, and this may be attributed to incompelet mineralization of OSW during composting. While, during vermicomposting the digested OSW, passess through their gut, thus the earthworms consume essential macro and micro nutrirents such as C, N, P, K, Fe, Zn, Mn, Cu, etc, to be used in metabolic reactions for growth and propagation, and mineralization of the OSW by the

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microbesthat lives their intestines, which can also immobolize heavy ametals in their bodies.therefore, the metabolic essential nutrient content in the vermicompst is lower of that in the compost.This findings are suported by the high CEC value of the studied compost.These results are in concistent with those reported by [59,42,2,4].

Total Sodium Percentage (TNa%)

The total sodium percentage (TNa%) in the studied compost was (0.44%), more than that of vermicompost, which was (0.26%) (Table 2). Composting the OSW through the vermicomposting technique significantly reduced sodium in the final product of the vermicompost. This may refer to the fact that the earthworms and associated microbes in their gut consume the Na for metabolic and exchange reactions, mineralization and transformation processes. high levels of the Na in the compost product affect soil properties and plant water uptake. The studied vermicompost product, which has a low Na content, can be used as an organic amendment in sustainable farming as an organic fertilizer due to its suitability in boosting in soil fertility and health for the long term. [58] stated that the existence of moderate levels of Na in the compost product has no adverse impact on soil properties, while the high levels of sodium will influence the soil structure and soil porosity, leading to alkaline soil that is toxic to plants. In turn, all these will affect water infiltration into the soil, water movement and percolation in the soil, soil air exchange, and soil organism activities in organic matter decomposition and nutrient availability to plants because of the osmotic effect of salt, especially Na. These results agree with those stated by [35,7,4].

Heavy metals

Regarding the Heavy metals (HMs) concentration in the compost prouducts. The concentration of lead (Pb^{2+}) in the studied compost was (490.4 mg kg-1) higher than that of the vermicompost, which was (410.91 mg kg^{-1}) (Table 3). Their concentration in both studied compost types surpassed the suggested limit (300 mg Pb^{2+} kg^{-1}) by [55] for non-limited use compost in farming. Whereas, depending on the national regulation of European Union standards, the Pb concentration in the studied composts remains within the permissible range of Pb^{2+}(150–500)mg kg^{-1} [17]. The reason behind the low concentrations of Pb^{2+} in the studied vermicompost is evidence of the ability of worms to remove the HMs from the cast materials in their gut by sequestration and binding them with the organic ligands or adsorbing them to their skin, as well as their ability to remove toxic materials through their gut. Furthermore, the worms are capable of accumulating and redistributing HMs in their bodies, which decreases their bioavailable levels of HMs in the vermicompost product. These results are matched with those reported by [52,4].

Table: (3) shows heavy metal concentration in studied compost and vermicompost.

Heavy metals	Compost	vermicompost
Total Lead (T Pb^{2+}) (mg. Kg^{-1})	490.4	410.91
Total Cadmium (TCd^{2+}) (mg. Kg^{-1})	24.423	17.49
Total Chromium (TCr^{6+}) (mg. Kg^{-1})	414.30	308.62

The Cadmium (Cd)

The cadmium (Cd) is a highly toxic, nonessential element for plants and has a grave impact on human health concerns, this is due to its mobility in the soil and its tendency to accumulate in edible parts of the vegetables. The concentration of Cadmium (Cd^{2+}) in the studied compost was (24.42 mg kg^{-1}) higher than that in vermicompost (17.49 mg kg^{-1}), (Table 3). In both studies of compost, the Cd^{2+} concentration was more than the accepted levels (1 to 3) mg kg^{-1} according to the United States Environmental Protection Agency [55,18] (0.7-10) under the EU guidelines and German standared 150 mg kg^{-1}, [17] for agronomic purposes. While concentration of Cd^{2+} in both studied compost was lower of that range suggested by USA biowaste, (39 mg kg^{-1}), [17]. The low concentration of Cd in vermicompost refers to the ability of worms to decrease the bioavailable forms of Cd during the passage of the digestive OSW in their gut, as well as via immobilization in their cell, transformation, and adsorption onto the humified organic solid wastes by the microbes that live in their gut. These results are compatible with those stated by [2,49,4], who reported that worms during vermicomposting can reduce significant concentrations of HMs in the vermicompost humified organic matter. However, even after removing a significant concentration of Cd from the vermicomposted materials. Whereas, its level (17.49 mg/kg) remains a concern, and it needs to be taken care of in dealing with it and to be used for the production of non-edible plants, such as forests or ornamental plant cultivation, or to be mixed with clean materials.

The Chromium (Cr)

Whereas, the total concentration of Chromium (Cr) was also higher (414.30 mg kg^{-1}) in compost compared to its level in vermicompost (308.62 mg kg^{-1}) (Table 3). [50] stated that the commonly permissible level of Cr in the compost products ranges between (100 - 500) mg kg^{-1}, with more toxicity of the Cr^{6+} form because of its greater possibility of carcinogenicity. Concentrations of Cr in the studied compost and vermicompost were higher than those suggested by [18], (210 mg kg^{-1}) and the EU guidelines (200-700) mg kg^{-1}, but less than that suggested by USA biowaste, 1200 mg kg^{-1}, German standared 150 mg kg^{-1}, German standared 3 mg kg^{-1}, [17]. The concentration of Cr in vermicompost was less than that in compost. This may be attributed to the fact that during the passage of the fed OSW in the gut of the worms, it transforms the Cr to be less mobile and bioavailable by the action of the associated microorganisms in their gut that release enzymes that reduce the more toxic form of Cr^{6+} to the less toxic Cr^{3+}

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form during the vermicomposting process, finally decreasing its environmental seriousness. Similar results were reported by [52,4]. Due to the high concentration of Cr, particularly in the studied compost product, it is advised to monitor the state of Cr in the soil, especially in those lands cultivated with the food crops and vegetables.

Biologecal Parameters

The studied compost and vermicompost qualities were tested in terms of biological safety use. The total bacterial count, total yeast and mold count in compost were (1.7×10^8 CFU g^{-1}) and (2.6×10^4 CFU g^{-1}) respectively, while their count was lower in vermicompost which were (5.5×10^6 CFU g^{-1}) and (8×10^2 CFU g^{-1}) respectively in (Table 4). The detected total coliforms count and Escherichia coli (E. coli) in the compost were (4.00 bacteria g^{-1}) and (110 bacteria g^{-1}) respectively, but not detected in the vermicompost.

Total Heterotrophic Bacterial Count

The total bacterial population was higher in compost (1.7×10^8 CFU/g) compared to that in vermicompost (5.5×10^6 CFU/g). This difference in their count may be refer to the composting techniques that used in converting OSW to compost. This demonstrated by [28] who reported that during composting OSW to compost the process passes through thermophillic pathway, and through which the temperature rises to (45–65)°C which known as a thermophilic phase.Composting typically enhances microbial reproduction during initial degradation of OSW. Whereas, converting the OSW to vermicompost in the gut of earthworms, that passes through mesophilic phase. In this pathway the tempeature degrees rises to (25–30)°C. Although the microbial community highly diverse in vermicompost, but the overall CFU count in it may be lower due to more stablity and maturity of organic matter. These results follow the same trend of those found by [51] who found that the initial bacterial count in the composts were higher of that in vermicompost. Whereas vermicompost exhibited more diverse functional and stable microbial groups, particularly nitrifying and phosphate solubilizer bacteria.

Table (4): Shows some of the biological properties of the studied compost and vermicompost.

Biological tests	Compost	Vermicompost
Total heterotrophic bacterial count ($CFU.g^{-1}$)	1.7×10^8	5.5×10^6
Total yeast and mold count ($CFU.g^{-1}$)	2.6×10^4	8×10^2
Total Coliform (MPN g^{-1})	4.00	Non
Escherichia coli (E. coli) (Bacteria g^{-1})	110.00	Non

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Total fungi count

[9] reported that fungi can live in strict conditions; they are responsible for compost maturation and degrade various origins of carbon, primarily lignocellulosic polymers and composites, and also polyaromatic carbon polymers. Fungi can restrain plant diseases, improve soil fertility, and promote mushroom growth. As well as they used in treating polluted soils with a wide range of pollutants. The total count of fungi in the studied compost and vermicompost was (2.6×10^4 and 8×10^2) CFU g^{-1}, respectively, with a higher count in compost than in vermicompost (Table 4). This is attributed to the fact that the sugar, starch, and protein in the organic materials fed to the earthworms decompose rapidly in their gut. Whereas, other organic matter components, such as cellulose and lignin, that resist or slowly decompose in the worm's gut remain in the compost, which is considered a good medium for fungal growth. The higher count of fungi in the compost may be related to the fact that during aerobic (hot) composting of the organic matter, the temperature at the thermophilic stage of decomposition will rise to more than 45°C, which kills the fungi, while it starts to grow again to dominate in the mesophilic phase (cooling down stage) of decomposition and starts with other decomposers in degrading lignocellulose compounds. Similar results were stated by [9,53,22,45].

Total Coliforms and Fecal Coliform (E. Coli) bacteria

The existence of total coliforms and E. coli in the studied compost and vermicompost, 4.00 MPN g^{-1} and 110 bacteria g^{-1}, respectively (Table 4), is a signal of the capability of the compost to cause health risks due to insufficient or incompatible curing of the thermophilic phase. While vermicompost was free from total coliform and E. coli pathogens, which indicates that it is sanitized well and of safe quality to use in vegetable farming. The absence of coliform and E. coli in the studied vermicompost is evidence of effective vermicomposting in removing the pathogenic microbes and vermicompost maturation. As well as worms can decreases or remove the coliforms pathogens of fecal coliforms (E.coli), when it passes through their guts as aresult of generation antimicrobial compounds through digestion process and competition by beneficial microbes. Relying on the [56] specification for the biological solid waste (compost Class-A), the counts of E. coli in compost should be less than (1,000 CFU g^{-1}), to be used safely in farming crops and vegetables. Therefore, the studied compost, according to [56] standards, requires more curing time for maturation and additional sanitization to be used safely in farming or may be used restrictively as is in farming non-consumed food by animals and humans.These results agree with those reported by [59,38,37].

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