Evaluation of Physio-Chemical Characteristics of Bio Fertilizer Produced from Organic Solid Waste Using Composting Bins

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Abstract: Background: The possibility of converting the organic fraction of municipal solid waste to mature compost using the composting bin method was studied. Nine distinct treatments were created by combining municipal solid waste (MSW) with animal waste (3:1, 2:1), poultry manure (3:1, 2:1), mixed waste (2:1:1), agricultural waste (dry leaves), biocont (Trichoderm hazarium), and humic acid. Weekly monitoring of temperature, pH, EC, organic matter (OM percent), and the C/N ratio was performed, and macronutrients (N, P, K) were measured. Trace elements, including heavy metals (Cd and Pb), were tested in the first and final weeks of maturity. Results: Temperatures in the first days of composting reached the thermophilic phase in MSW compost with animal and poultry manure between 55–60 °C, pH and EC (mS/cm) increased during the composting period in most composting bin treatments. Overall, organic matter (OM percent) and the C/N ratio decreased (10.27 to 18.9) as result of microbial activity during composting. Organic matter loss percent was less in treatments containing additives (biocont l humic acid) as well agricultural waste treatment. Composting bin treatments with animals and poultry showed higher K and P at the mature stage with an increase in micronutrients. Finally heavy metals were (2.25–4.20) mg/kg and (139–202) mg/kg for Cd and Pb respectively at maturation stage. Conclusion: Therefore, the results suggested that MSW could be composted in the compost bin method with animal and poultry manure. The physio-chemical parameters pH, Ec and C/N were within the acceptable standards. Heavy metals and micronutrients were under the limits of the USA standards. The significance of this study is that the compost bin may be used as a quick check to guarantee that the outputs of long-term public projects fulfill general sustainability requirements, increase ecosystem services, and mitigate the effect of municipal waste disposal on climate change particularly the hot climate regions.

Keywords: MSW; compost bin; organic matter; C/N; heavy metals

1. Introduction

Globally, urbanization and the continual growth of the human population have resulted in the development of massive amounts of trash. These waste streams have created a slew of environmental, social, and economic concerns, particularly in poor countries [1]. Each day, a substantial volume of municipal solid waste (MSW) is created and disposed of in landfills at a rate of less than 6% recycling and composting [2]. MSW management is without a doubt one of the most serious environmental concerns facing the world, especially in metropolitan areas. If not correctly treated, it may have a negative impact on the environment by creating a disagreeable odor, causing leachate, and emitting greenhouse gases. Landfilling is the primary method of disposing of MSW in the vast majority of nations globally, regardless of per capita wealth [3]. However, this treatment method has been criticized because of its high environmental impacts and incompatibility with the
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The concept of a circular bioeconomy [4]. Composting, as a less expensive and sophisticated method, may be used in place of landfills for organic waste recycling. Due to their high organic matter and mineral contents, municipal solid wastes may be utilized to improve soil fertility. Composting is an effective technique for generating a stabilized material that may be utilized in fields as a source of nutrients and soil conditioners [5]. Composting is an aerobic and exothermic process that is used globally to treat biodegradable trash and convert it into a soil conditioner and fertilizer. Additionally, it is the most ecologically beneficial technique of garbage disposal when compared to other processes, such as incineration, landfilling, and anaerobic digestion [6]. Composting has been shown to be an effective method of increasing crop productivity and soil quality. Composts include plant nutrients, particularly nitrogen and phosphorus, as well as organic substrates. As a result, it has the potential to influence a soil’s physical, chemical, and biological quality [7]. Natural composting is a lengthy process, but land scarcity and vast amounts of MSW demand that these wastes be handled more rapidly. The amount and composition of organic matter in compost are critical in determining the product’s quality [8,9]. Chemical parameters of composts, such as electrical conductivity (EC), pH, nutrient levels, organic matter, C:N ratio, and heavy metal concentration, have been utilized to determine their maturity and stability [10,11]. Three stages of composting were observed: the mesophilic stage increased temperature from ambient to 40 °C; the thermophilic stage characterized temperatures between 50 °C and 60 °C due to microbial activity during composting with the aid of passive or active aeration (turning composting bin) and moisture content between 40% and 60%). When the temperature reaches 60 °C, the breakdown process becomes sluggish, and microbial activity is restricted to thermotolerant bacteria. After 2–3 weeks, the temperature of the compost began to decrease and did not return to normal after turning. This is the cooling stage, during which the compost reaches stability after a period of time when it is resistant to decomposition. The factory for organic solid waste recycling in Al-Youssoufia City collects MSW collected from neighboring communities in southern Baghdad. The MSW comprised reusable organic materials as well as plastics and glass. The majority of this trash is disposed of in landfills. The present research aimed to convert the organic portion of MSW to biofertilizer using aerobic bin composting and to characterize the physicochemical properties of the compost. Urbanization and industrialization have created a slew of issues for garbage management. Pollution of the environment and garbage creation have a direct effect on biological diversity. Without proper treatment, haphazard discharge of solid waste into the environment may have negative consequences, resulting in contamination of all resources. Enhancing the pace and degree of degradation may provide considerable benefits in terms of optimizing the composting duration, quality, and production of the compost. This is accomplished by the addition of different chemicals to the composting process.

The purpose of this research is to determine the physicochemical properties of municipal solid trash in the presence of different additives, most of which are industrial waste products. The following goals were established for the research Composting of Solid Waste in Baghdad City Using Various Additives:

1. To discover and choose additives for organic waste stabilization.
2. To determine the viability of combining organic wastes for stabilization
3. To determine the physio-chemical parameters necessary for organic waste stabilization.
4. Performance evaluation of the method when coupled with various types of stabilized organic waste.
5. To compare the organic matter lose percent during composting duration.
6. To ascertain the presence and characteristics of heavy metals in solid waste.

2. Materials and Method

2.1. Feedstock and Composting Materials Used in the Composting Bin Methods

From September to December 2020, the composting was performed in the garden of the College of Science for Women at the University of Baghdad using the aerobic
bin composting technique at an ambient, and compost maturity was monitored until March 2021.

Composting materials included MSW (which was previously crushed and sieved in the factory), which was the primary component of the composting process. The MSW was transported from a waste treatment and recycling facility in the district of the al-Yusufiya factory, approximately 20 km south of Baghdad. The dried animal and poultry manure utilized in the various mixtures was supplied by the Abu-Ghraib district’s College of Agriculture Science.

Quality control and assurance has been provided for technical guidance in addition to the quality control and assurance of geosynthetics used to contain waste, as well as manufacturing quality assurance and control of these materials. It covers all types of waste containment facilities, including hazardous waste landfills and impoundments, municipal solid waste according to local and international standardization, and Starting with elaboration of sampling plan in accordance with the relevant guidelines and standards.

2.2. Design and Composting Methods

To construct compost heaps, composting bin scale composting was used, mostly via the use of composting containers [12,13]. Composting bin technique scale tests were performed in plastic containers (0.4 m × 0.4 m × 0.90 m). For aerobic composting, holes with a diameter of 1.5 cm were drilled at equal intervals in each container, approximately six rows on each side, to ensure aerobic composting. Composting bins were physically turned twice a week for the first two weeks and then weekly until week 14. During the composting process, the moisture content of the compost should remain between 40% and 60%. Following the mixing of compost mixes, a thin layer of old compost was applied to the heaps to maintain warmth and moisture throughout the first stages of the composting process. Temperatures were taken daily for the first four weeks and thereafter weekly. For physio-chemical analysis, samples were gathered weekly after rotating the composting bin and then every two weeks, as previously stated. Samples were obtained from the center and margins of the organic waste composting bin and then combined in plastic bags to guarantee homogeneity of the sample for analysis. Composting took 14 weeks, but maturation and curing extended the process to 26 weeks. Each compost container was sieved using five-millimeter sieves. Weighing and removing nonbiodegradable particles from each compost treatment.

2.3. Experimental Design

Compost materials included the organic fraction of MSW, animal, poultry (chicken) manure and agricultural waste. Composting research employed the organic part of municipal solid waste as a starting material and animal, poultry, and agricultural waste as a bulking agent. The study involved nine main treatments consisting of the organic fraction of municipal solid waste mixed with different percentages of animal, poultry manure and agriculture waste. Biocont (Trichoderma hazarum 19 × 10⁷ spore in 1 g) and potassium humate (K₂O 12%) as a source of carbon and nutrients [13] were added as separate treatments. Table 1 presents some of the physiochemical characteristics of the organic solid fraction (OSF) of municipal waste and the mixture of OSF with different bulking agents. The following treatments were used in the current study:

- Composting bin 1: 100% organic solid waste (control).
- Composting bin 2: organic solid waste: animal manure 3:1 (75:25) (w/w) %.
- Composting bin 3: organic solid waste: poultry manure (chicken manure) 3:1 (75:25) (w/w) %.
- Composting bin 4: organic solid waste: animal manure (2:1) (67:33) (w/w) %.
- Composting bin 5: organic solid waste: poultry manure (2:1) (67:33) (w/w) %.
- Composting bin 6: organic solid waste: agriculture waste 9:1 (90:10) (w/w) %.
- Composting bin 7: organic solid waste: animal manure: poultry manure (2:1:1) (50:25:25) (w/w) %.
Composting bin 8: organic solid waste: Bicont (100:2) (w/w/v) %.
Composting bin 9: organic solid waste: humic acid (100:2) (w/w/v) %.

2.4. Analysis of Physiochemical Characteristics

Temperature was monitored daily by a thermometer using a metal probe to make deep holes to reach the thermometer to a depth of 25–30 cm. All sample analyses were performed in the Biology Department College of Science and Laboratory of Agricultural Science Collage/University of Baghdad. Subsamples (500 g) were collected from each composting bin after mixing the components of the composting bins to obtain a representative sample every two weeks, air dried in an open container, crushed to sieve 2 mm and kept in polyethylene bags until analysis in the laboratory. The samples were kept in a refrigerator at 4 °C for physio-chemical analysis. A range of physiochemical parameters were determined, including the following:

2.4.1 Moisture was measured after turning and watering the composting bin samples, and 10 g of wet composted samples was weighed and dried in an oven at temperature 105 °C for 24 h.

2.4.2 The pH and electrical conductivity (EC) of a water extract were evaluated by diluting one part of the compost by volume with 10 parts distilled water at a ratio of 1:10 (w/v). The samples were shaken and allowed to precipitate before being filtered using the procedure described by [14], where both EC and pH has been calibrated with standard solutions.

2.4.2 The organic matter (OM) % and C% were calculated as the weight loss of the samples. Ten grams of composted sample was weighed and dried in an oven at 105 °C for 24 h and then ignited at 550 °C for 4 h. The difference in weight referred to as volatile substances and OM% was calculated according to the equations described by [15] as follows:

\[
OM\% = \frac{w1 - w2}{w1} \times 100
\]

where \(w1\) is the dry weight after 105 °C and \(w2\) is the weight after ignition at 550 °C.

\[
\text{Organic carbon (C\%) = } \frac{OM\%}{1.8}
\]

\[
\text{Organic matter loss (OM\%) = } 100 - 100 \times \frac{X1[(100 - X2)]}{X2[(100 - X1)]}
\]

where \(X1\) is an intial organic mater, and \(X2\) is the final value of organic mater.

2.4.3 Macro-Nutrients (N,P,K) total nitrogen was determined by the modified Kjeldahl’s method. The composted samples were digested in concentrated H\textsubscript{2}SO\textsubscript{4} [16].

Total potassium was measured by the flame method using a flame photometer, and total phosphate was measured by a spectrophotometer at 882 nm by Jackson, 1973; After Prepare a series of Standard Solutions from the Stock Solution.

2.4.4 Mineral elements such as Cu, Zn, Mn and Fe as well as heavy metal concentrations (Cd and Pb) were determined by digestion of compost with concentrated H\textsubscript{2}SO\textsubscript{4} and concentrated H\textsubscript{2}Cl\textsubscript{2} and atomic absorption spectrophotometry by Lindsay, W.1978.

3. Results and Discussion

3.1. Chemical Composition of Organic Wastes in Composting Bins

Municipal organic waste is one of the possible nutrient-rich organic leftovers that, when recycled, yields a useful and nutrient-dense product called compost.

The organic part of the trash was discovered (pH 6.7) and included a rather small amount of total nitrogen (1 percent). The organic carbon (C\%) was 29.2%, with a C:N ratio of 29.272. The chemical features of OFSW (Table 1) indicated that it should be treated with additional nutrients to increase its value as an organic fertilizer. This would increase the microbial activity, stability, and maturity of the waste by composting. Provided a supply
of nitrogen to maintain an optimal C/N ratio, as well as organic waste rich in N, P, and K nutrient [16–18]. Animal manure, chicken dung, and agricultural waste are all high in nitrogen and have been used to replenish heaps to remedy nitrogen depletion, as well as animal manure and poultry as additives or inoculums for compost treatment, which is beneficial for producing high-quality fertilizer or substrate hater 2015).

Table 1. Physio-chemical characteristics of raw and mixtures of composted materials.

| Raw Materials and Their Mixture Used in the Composting Bins | pH  | EC (ms/cm⁻¹) | Organic Matter (OM)% | C (%) | N (%) | C:N (%) |
|-------------------------------------------------------------|-----|--------------|----------------------|-------|-------|---------|
| Unmixed                                                     |     |              |                      |       |       |         |
| Bin 1: OSFW * (100%)                                        | 6.70| 3.8          | 52.69                | 29.272| 0.99  | 29.5    |
| Mixtures                                                    |     |              |                      |       |       |         |
| Bin 2: OFSW + Animal manure (3:1) (75% + 25% by weight)     | 6.47| 4.100        | 62.182               | 34.55 | 1.18  | 29.42   |
| Bin 3: OFSW + Poultry manure (3:1) (75% + 25% by weight)    | 6.73| 4.375        | 63.56                | 35.310| 1.435 | 24.61   |
| Bin 4: OFSW + Animal manure (2:1) (66% + 33% by weight)     | 6.49| 4.63         | 66.53                | 36.96 | 1.15  | 32.248  |
| Bin 5: OFSW + Poultry manure (2:1) (66% + 33% by weight)    | 6.53| 4.66         | 64.21                | 35.67 | 1.31  | 27.238  |
| Bin 6: OFSW + Agriculture waste (9:1) (90% + 10% by weight) | 6.90| 4.03         | 54.193               | 30.11 | 1.05  | 28.713  |
| Bin 7: OFSW + animal + poultry manure (2:1:1) (50:25:25) (w/w/v) % | 6.85| 4.47         | 68.65                | 38.14 | 1.7   | 22.433  |
| Bin 8: OFSW + Bicont (100: 2) (w/w/v) %                     | 6.8 | 4.475        | 49.48                | 27.49 | 1.08  | 25.457  |
| Bin 9: OFSW + Humic fulvic acid (100: 2) (w/w/v) %          | 6.81| 3.67         | 52.36                | 29.09 | 1.4   | 20.786  |
| Standard values suitable for composting Source: Standard [19–21] | 5.5–8.0 | -          | >20                  | 30–40 | >0.6  | 25–50:1 |

* Organic fraction of solid waste.

The present study’s findings indicated that proportioning mixed wastes in the mixes in Table 1 resulted in a good C/N ratio in heaps 1–9, which varied between 20.786 and 32.248, as many studies have largely agreed.

3.2. Physical and Chemical Characteristics

3.2.1. The Effect of Temperature

The temperature pattern indicates the presence of microbes and the beginning of the composting process. Daily temperature readings for each bin were taken, and the weekly average was calculated. Refer to Figure 1. Temperatures increased in the majority of compost heaps to values between 55–60 °C in combination wastes with varying percentages of animal and poultry manure during the early stages of the composting process. Gradual temperature increases to the thermophilic stage (40–60 °C) over the three-week composting process, indicating microbial breakdown of organic solid waste. The temperature decreases after the sixth week and then stabilizes indicating that the organic part of garbage has decomposed into compost [22,23]. Due to extended maturation period temperature increased at last weeks of maturation lined with increased ambient temperature (27–29 °C) in March. Throughout the composting process, the moisture level was maintained between 40% and 60%.

3.2.2. Effect of pH

At the start of the composting process, the pH of MSW and its combinations with varying degrees of acidification was between 6.5 and 6.8. Reduced pH at the start of composting indicates the development of organic acids, which subsequently became more basic in all compost bins and reached more than 7 in all waste after two weeks (Figure 2). Gradual increases in pH throughout the composting process restrict fungal development that thrives in an acidic environment, while aeration holes and regular composting bin turning minimize CO₂ trapped in the empty space between compost particles [24]. At the curing stage, the pH value of compost bins is approximately 8 as a consequence of decreased microbial activity and organic acid generation agreed with study [25–27].
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Figure 1. Temperature changes during the decomposition of organic waste in different composting bins.

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Figure 2. pH changes during the composting period in composting bins (1–9).

3.3. Electrical Conductivity (EC)

The EC value is critical to monitor during the composting process because it indicates the saltiness of the composted materials and their appropriateness for plant development. The present study discovered a considerable change in EC values throughout the composting process as a result of nutrient release. In comparison to the control and other compost combinations, the greatest EC values reported with compost mixtures of animal and poultry manure in the sixth week varied between 4.5–5.05 mS/cm (Figure 3). At the conclusion of the composting process (Figure 3), the EC value for MSW and combined organic wastes was substantially higher than the EC value for MSW alone. Poultry chickens have a higher concentration of soluble salts because of the animal food they consume, but compost created from a combination of organic matter other than manure and plant material has a lower concentration of soluble salts [28]. EC values rise during organic matter degradation when inorganic compounds are formed, and the relative concentration of ions increases owing to waste mass loss [5]. The EC values for all compost combinations decreased as they matured as lined with study [29], while others showed an increase. There was a slight rise in EC values due to co-composting with organic additives [6,11,12,30]. As previously stated, the optimal EC value for developing plants is <4 dS m$^{-1}$.
The EC value is critical to monitor during the composting process because it indicates the completion of the process (compost maturity). By and large, all waste mixtures exhibit a drop in organic carbon throughout the composting process as a result of organic matter breakdown. Figure 4. The C/N ratio for each composting bin ranged from (20.79 to 32.25) that percent which is closely to preferred C/N ratio stated in Doughtry 1998 the early stage of composting, decreased progressively as the substrate decomposed, and reached (10.27 to 18.9) percent during the mature stage, when it marginally decreased. Certain compost bins exhibit a slight rise in the C/N ratio, which might be due to ammonia volatilization under alkaline conditions with a low C/N ratio, as shown in compost bins 6 and 9 or bacteria extract nitrate or another nitrogenous molecule from compost, as well as compostingbin.2 resulted an increase in C /N in third week lined with [21] study when C/N increased during composting MSW alone at third week of composting process [30,31].

Figure 4. Changes in the C/N ratio during the decomposition of organic waste in different composting bins.

The drop in the C/N ratio might be the consequence of organic carbon being converted to carbon dioxide, followed by a decrease in the amount of organic acid. The reduction rate of C/N lowered between 6th–8th week agree with [32] study on food waste composting that TOC were more stable in 6th week. When the C/N ratio was less than 20, the compost was
considered mature and may be utilized without limitation. Compost used in agriculture must have a C/N ratio between 12 and 18 [33,34].

The overall average organic matter (OM percent) content of the compost bin treatments varied between 41.93 and 53.3 during the composting period (Table 2). The organic matter loss was greater in compost bins 5 and 7 especially during thermophilic phase, where the average OM percent was considerably different from the MSW treatment. The addition of animal or poultry manure accelerated organic matter degradation in comparable rates between compost bin 2 and 3 but higher reduction when wastes mixed together in composting bin 7 this due to higher organic matter content. The reduction rate was lower in wastes containing Compost bin 8 with Biocon. additives did not promote microbial activity in the same way that the Trichoderma hazarium spore suspension did in study [35]. The addition of potassium humate to MSW throughout the composting process had no effect on microbiological activity and increased degradation rate. Concerning compost quality, mature compost meets the standards for EU guidelines (>15), and the CCQC recommends a minimum organic matter concentration of 25%.

Table 2. Organic matter (OM%) initial, mature, mean and organic matter losses in different treatments.

| Composting Bin | OM% Initial | OM% Mature | OM% Mean | OM Loss |
|----------------|-------------|------------|----------|---------|
| 1              | 52.69       | 35.08      | 41.93    | 25.85   |
| 2              | 62.18       | 32.93      | 46.50    | 41.61   |
| 3              | 63.56       | 32.67      | 44.92    | 40.10   |
| 4              | 66.53       | 38.44      | 49.78    | 38.82   |
| 5              | 64.21       | 31.15      | 45.90    | 43.74   |
| 6              | 54.19       | 38.23      | 46.88    | 26.81   |
| 7              | 68.65       | 42.15      | 53.32    | 46.68   |
| 8              | 49.48       | 39.12      | 43.79    | 18.32   |
| 9              | 52.36       | 40.11      | 46.41    | 16.095  |

Week means 59.32 36.65 LSD composting-bin * week 2.352

* Relation of avg. composting bin with weeks.

3.5. Effect of Nutrients (N, P and K) on the Composting Process

Generally, MSW mixed with animal manure and chicken poultry has an acceptable nitrogen percent for agricultural purposes. The variation between the initial and final values for compost due to microbial activity leads to an increase in the degradation of organic matter and loss of carbon in the form of CO₂ and the contribution of nitrogen-fixing bacteria, which are responsible for the increase in total nitrogen content at the mature stage [34]. After maturity, the present study found the highest nitrogen level in compost bins 4 and 7 (2.08% and 2.05%, respectively) and the lowest nitrogen content in composting bin 6 (1.120%), which is consistent with previous research on composted solid waste (Al-Turki, El-Hadidy, and Al-Romian 2013). Nitrogen loss was also detected at the mature stage as ammonia volatilization or immobilization processes, which were encouraged by high pH values (between 7.7 and 8.2), as evident in composting bins 5 and 9 [36,37].

Additionally, phosphorus and potassium are key minerals for plant growth. Generally, total phosphorous is represented as a percentage (%) of dry weight. The amount of P % in the initial stage of decomposition varied between 0.320 and 0.649% in all composting bins (Table 3) and increased in the majority of composting bins during the final stage of the composting process as the compost cured. In composting bin 7 (organic solid waste:animal manure:poultry manure) (2:1:1), a slight increase in P percent was observed, ranging from 0.320 to 0.860%. Phosphorous loss (decrease) during composting may be attributed to phosphoric compound consumption in cell development or leachate. However, compost
made from organic waste and poultry manure combined at a 2:1 ratio in composting bin 5 has a greater P percent content during the mature stage of decomposition. The current study’s findings corroborated those of [38].

Table 3. Initial and final N, P and K contents in the composting process.

| Composting Bins | Time (Week) | N%    | P%    | K%    |
|-----------------|-------------|-------|-------|-------|
| 1               | 0           | 0.990 | 0.410 | 0.565 |
|                 | 26          | 1.50  | 1.1   | 1.300 |
| 2               | 0           | 1.17  | 0.325 | 0.550 |
|                 | 26          | 1.520 | 0.695 | 1.510 |
| 3               | 0           | 1.435 | 0.320 | 0.565 |
|                 | 2           | 1.31  | 0.850 | 1.550 |
| 4               | 0           | 1.150 | 0.575 | 0.155 |
|                 | 26          | 2.08  | 1.390 | 1.370 |
| 5               | 0           | 1.310 | 0.649 | 0.610 |
|                 | 26          | 1.170 | 0.621 | 1.220 |
| 6               | 0           | 0.355 | 0.355 | 0.674 |
|                 | 26          | 1.120 | 1.200 | 0.775 |
| 7               | 0           | 1.700 | 0.642 | 1.190 |
|                 | 26          | 2.050 | 0.860 | 1.570 |
| 8               | 0           | 1.080 | 0.335 | 0.545 |
|                 | 26          | 1.330 | 0.520 | 0.705 |
| 9               | 0           | 1.400 | 0.624 | 0.800 |
|                 | 26          | 1.230 | 0.335 | 0.900 |
| LSD composting bin |       | 0.024 | 0.025 | 0.018 |

The total potassium concentration ranged between 0.155 and 1.19% in all composting bins at the start of the composting process and concentrated toward the conclusion of the procedure, particularly for waste mixed with poultry manure. Additionally, the findings indicated that the compost generated from organic mixed materials in composting bin 7 (MSW:Animal: Poultry) (2:1:1) had a greater K level than the other treatments, owing to the waste including poultry manure, which is a source of K. In most composting composting bins, the initial K percent was acceptable; this agrees with recent research that found animal manure had a lower K percent value than herbal plants and sugar cane [9,25].

3.6. The Effect of Heavy Metals on Composting Characteristics

The potential availability of Cd, Cu, Pb, and Zn increased with the age of compost due to the loss of organic matter from decomposition, and Fe was less toxic than other heavy metals because of the alkaline pH of compost [39]. The final values obtained for Cd, Pb, Cu, Zn, Mn and Fe were lower than the USA limits [40].

Based on the obtained results for the heavy metal content of composts (Figure 5), it can be concluded that the chemical analysis of heavy metals showed that Cd was higher in MSW and its mixtures in the beginning; after the composting process, the Cd decreased significantly, while it was lower in compost bins 1, 2 and 3 mixed with animal or poultry manure. However, the concentration of Cd largely decreased to lower levels after maturation, while the concentration of heavy metal Pb was increased in all composting bins after maturation [41].
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Figure 5. Heavy metal concentrations (mg/kg) at the beginning and end of maturation compost.

4. Conclusions

The current study was conducted to determine the effect of organic additives on the composting process of municipal solid waste collected from Baghdad’s municipal solid waste processing unit. Numerous physicochemical elements influence the degradation process during composting, and the pH, EC, organic matter, total nitrogen, and C/N ratios of compost were all within the standards. Animal and poultry manure is an excellent source of bacteria and a bulking agent during the composting process. The macronutrient (N, P, and K) composition of manufactured compost is considered average when compared to compost made from animal and poultry manure and is not regarded as a cause of nutrient pollution in the environment. While the concentrations of Cu, Zn, Mn, and K increased during composting, the heavy metals and micronutrients remained below the permissible limits set by the USEPA for compost. Centralized waste management techniques become inadequate in an era of population boom. Demonstrating accessible alternatives and demonstrating the advantages of trash processing at the household level can motivate many individuals to take responsibility for their own rubbish.
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