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The Influence of Agricultural Residues and Horse Manure on Chemical and Biological Properties of Soil

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ABSTRACT

Animal droppings are essential for agriculture because they are rich in organic matter and nutrients that support plant growth. The application and management of manure from domestic animals are crucial for the sustainability of agricultural practices. Nevertheless, diseases and unbalanced nutrient contents in unprocessed manure can seriously endanger the environment and public health. This study examines the chemical, bacteriological, and faunal diversity of fresh and decomposing horse dung mixed with agricultural waste. The mixture was analyzed on the first day of the composition process and repeated eight months before field application.

Frequent assessments of fresh and mature manure have been conducted to monitor faunal diversity. In addition, a light trap was used for an entire year to count the most common scarab species (*Phyllanthus excavatus*). The levels of faecal coliform bacteria (<100 CFU/g) and Streptococcus (2 x 10^2 CFU/g), total nitrogen (5,320 ppm), available phosphorus content (20.8 ppm), available potassium content (1,300 ppm), organic matter (190.0 g kg^{-1}), and organic carbon (110.0 g kg^{-1}), decreased in the mature manure mixture compared with the fresh one. Other measurements indicating a notable increase included total viable heterotrophic bacteria (6.8 x 10^5 CFU/g) and Actinomyces (4 x 10^3 CFU/g), as well as total potassium content (10,000 ppm), available nitrogen content (224 ppm), and total phosphorus content (1,064 ppm). The fresh mixture contained more insect species (twenty species) than the mature mixture (only nine species), including various species of ants, cockroaches, immature fly stages, earwigs, beetles, and woodlice.

In contrast, woodlice and multiple stages of scarab species dominated the mature mixture. The scarab *Phyllognathus excavatus* was highly prevalent, especially in October and November (70% of the population). Exploring the role of terrestrial biota and associated microflora on soil fertility and nutrient cycling dynamics is crucial for sustainable agricultural practices.

INTRODUCTION

A manure pile represents a significant resource in the farm that can be a valuable asset that effortlessly transforms into nutrient-rich compost, increasing crop yields and safeguarding the environment is ideal. This metamorphosis is a tangible outcome of sophisticated composting methods combined with a profound comprehension of microorganisms and ecological dynamics [1]. Manure can be controlled and used effectively via biomimetic agricultural practices to turn potential problems into valuable opportunities. Biological elements vital in nutrient mineralization and decomposition in terrestrial ecosystems include soil bacteria [2].

Horse dung is an important agricultural resource because of its high nutrient content, including nitrogen, phosphorous, and potassium derived from undigested plant material, urine, and bedding [3]. In addition, horse manure is physically well suited for composting because of its balanced carbon-nitrogen ratio (C:N) and moisture content, which are essential for the optimal decomposition process. The organic matter in horse manure breaks down quickly when exposed to the right microbial and environmental conditions, ensuring that nutrients such as nitrogen, phosphorus, and potassium are available to plants in more stable and bioavailable forms [1]. Microorganisms such as *Bacillus* spp., *Pseudomonas* spp., and fungi, including *Aspergillus* and *Penicillium* species, are particularly effective in horse manure's decomposition and nutrient cycling during composting [4]. These microorganisms, which are either added as inoculants or occur naturally in manure, contribute significantly to the breakdown of organic matter and make horse manure a highly effective and environmentally friendly fertilizer. However, raw manure can sometimes be ineffective and even poses risks, including exposure to pathogens and nutrient imbalances [5].

Chastain [5] emphasized that horse excrement can be quickly converted into dark, nutrient-rich compost through microbiologically mediated bioconversion processes such as composting. This process, propelled by microbial activity and thermogenesis, eradicates pathogens and transforms nutrients into more bioavailable forms, enhancing soil texture and drainage while augmenting water retention. Additionally, composting enriches the soil with beneficial microorganisms that help distribute nutrients and promote overall soil health. In addition to microorganisms, Scarab beetles (Coleoptera) play a crucial role in this transformation. Their activities, including secondary seed dispersal, soil aeration, and nutrient enrichment, contribute significantly to dung decomposition [6]**.** Dung beetles enhance soil structure and water infiltration by burying and digesting dung, ensuring the availability of essential nutrients such as nitrogen and phosphorus for plant absorption [7]**.**

Integrating dung beetles into composting practices can optimize the process of converting animal waste into a valuable agricultural resource and complement the work of bacteria, fungi, and actinomycetes in breaking down raw manure into stable, nutrient-rich compost [8]**.** These beetles contribute to livestock health by diminishing fly populations and parasite illnesses. Their tunneling through the manure dries it out and kills parasitic nematode eggs, helping to reduce infection rates in pastures, improving animal health, supporting nutrient recycling, and promoting soil health [9]**.**

The United State Department of Agriculture (USDA) statistics underscore the importance of manure as a vital asset for agricultural enterprises. Initial efforts were aimed at raising farmers' awareness of the nutritional value of manure and promoting its use instead of chemical fertilizers. However, economic and demographic changes after World War II led to large-scale livestock operations and increased commercial fertilizer production, changing agricultural practices. Since that time, the use of manure has been acknowledged for improving crop yields. However, its efficacy is influenced by factors such as meteorological circumstances, soil characteristics, and manure quality.

For the first time in Egypt, the living organisms that contribute to the transformation of agricultural waste are being studied, in addition to their relationship to the chemical and microbiological properties of fresh and transformed waste. The study aimed to examine the composting process, including its chemical and microbial interactions and the biological contributions of various organisms. We investigated how manure can be converted and stabilized into nutrient-rich compost by assessing properties such as pH, organic matter, and nutrient content. In addition, we investigated the critical role of animal communities and microbial properties in organic matter decomposition and nutrient retention and how these organisms improve nutrient flow and soil health under Egyptian field conditions. Through this research, we aimed to promote sustainable, regenerative agriculture and soil quality restoration through improved composting practices. This research elucidates the significance of employing nature-based solutions to facilitate the ambitions of many countries in arid regions to expand their agricultural production.

MATERIALS AND METHODS

2.1. Study Site: Egypt, Eastern Desert's farms, Qalyubia Governorate, Ahmed Orabi Agricultural Association, Nature and Science Foundation field area (Lat/Lon: 30.247, 31.545**;** Elevation: 118m.)

2.2. Sampling

Three distinct samples of horse manure and agricultural waste were procured: 1. the fresh samples were obtained immediately after defecation (three samples); 2. the decomposed composite was extracted from the identical source after a duration of eight months of natural maturation (three samples). The third sample was acquired for the purposes of quality assurance and quality control (QA/QC) from the compost pile after complete maturation (after a period of 12 months) prior to its application in agricultural fields in Egypt. All samples were collected in aseptic containers and subsequently conveyed to the laboratory for comprehensive analysis.

2.3. Chemical properties

The soil sample was suspended at a soil-to-water ratio 1:2.5, which enabled accurate pH measurements in a standardized soil-to-water suspension. The pH was assessed via the methodology outlined by Page et al. [10 & 11] with a pH meter (HANNA HI 8520). The electrical conductivity (EC) was expressed as EC (ds/m) and measured with a Model 710 conductivity meter, according to Richard [12].

To determine the quantity of nutrients extractable with water, ten grams of manure samples were combined with 100 milliliters of distilled water, stirred on a mechanical shaker, and filtered for analysis [7]. The total carbon content was measured via the Walkley–Black method. The total nitrogen (TN) content was determined according to the technique of Black et al. [13]. Total phosphorus and available phosphorus were measured calorimetrically in 0.5 M NaHCO3 extract, according to Olsen [14]. The total potassium (TK) content of the ammonium acetate extract was quantified with a flame photometer according to Jackson's methodology [15]. The boron (B) amount was measured via Jackson's technique [16]. The contents of potassium, calcium, magnesium, soluble anions of HCO3- and Cl, and soluble cations of Ca2+, Mg2+, Na+, and K+ were determined according to Richard [12].

2.4. Microbial analysis

Microbial screening was conducted on fresh and aged horse manure samples. Isolation was performed via the standard pour plate technique on different media for each microbial group. All analyses were performed in triplicate, and the results are expressed as colony-forming units per gram of manure (CFU/g). The study included the following steps: total viable heterotrophic bacteria were counted on nutrient-rich agar via the standard plate counting method. The selective isolation of actinomycetes was carried out via starch-casein agar. Pseudomonas were identified and quantified via Pseudomonas-selective agar (e.g., cetrimide agar). Faecal coliform bacteria were detected via MacConkey agar. Faecal streptococci were detected via azide-dextrose broth and bile esculin agar.

2.5. Quality Assurance and Quality Control (QA/QC)

The final product was analyzed after full maturation to ensure the produced compost meets the consumer expectations and requirements according to Egyptian standards. The final product was analyzed in the Ministry of Agriculture and Land Reclamation laboratory (Department of Soil Fertility and Microbiology, Desert Research Center).

٢.6. Seasonal Abundance of *Phyllognathus excavatus,* and the distribution of other soil fauna

To determine the scarab beetle (*Phyllognathus excavatus*) seasonal abundance, a light trap was set up for two days at the start of each month for a whole year, from May 2022 to April 2023. Throughout the year, samples were gathered, enumerated, and the seasonal presence was recorded. The results were then visually displayed as an abundance percentage.

For soil fauna, heaps of horse manure and agricultural waste were examined once at the start of each month from the time the pile was formed in May 2022 to April 2023. Species were identified using taxonomic keys and the collection of Nature and Science

Foundation. It was challenging to determine the quantity (exact number) for each species within the waste pile because of the large number of species, their quick movement and dispersion, the variety of their instars, and their overlapping inside the pile. As a result, each species' levels of abundance were identified and documented monthly, this allowed for the determination of the rank of abundance of each species throughout the year using the following categories: High = ≥ 50 individuals/m^3. Moderate = 10 – 49 individuals/m^3. Low = 4 – 9 individuals/m^3. Rare = ≤ 3 individuals/m^3

The results of the observation were visually displayed as abundance ranks (high, moderate, low and rare).

RESULTS

3.1 Chemical properties

Table 1 presents the chemical parameters of fresh and mature horse dung and agricultural waste mixtures. Both samples (fresh and mature mixtures) were saline with minor differences, as the fresh mixture contained 2.14 ds/m, while that of the mature mixture was 2.4 ds/m. The mature mixture had a pH of 7.15, whereas the fresh mixture had a pH of 8.2, indicating that although it was initially alkaline, it gradually became more neutral. While the fresh mixture contained approximately 34.86% organic matter, the mature mixture presented a considerable reduction in the organic matter content, as the value decreased to 19%. The organic carbon content of the fresh mixture sample was 20.22%, which declined to 11% (mature mixture) after decomposition.

Table 1. Chemical parameters of fresh and mature agricultural waste and horse dung mixtures in Egyptian field conditions.

Property	Fresh mixture	Mature mixture (after 8 months)
EC value (ds/m)	2.14	2.4
pH	8.2	7.15

Organic matter (g kg^{-1})	348.6	190.0
Organic carbon (g kg^{-1})	202.2	110.0
Total nitrogen (ppm)	19,600	5,320
Available nitrogen (ppm)	112	224
Total phosphorous content (ppm)	325	1,064
Available phosphorous content (ppm)	248	20.8
Total potassium content (ppm)	4,200	10,000
Available potassium content (ppm)	1,700	1,300

The total nitrogen concentration of the fresh combination was 19,600 ppm, whereas the accessible nitrogen amount was 112 ppm. The total nitrogen content of the mature mixture was 5.300 ppm, whereas the available nitrogen content was 224 ppm. The fresh mixture's total and available phosphorus contents were 325 ppm and 248 ppm, respectively. In comparison, the total phosphorus content of the mature mixture was 1,064 ppm (approximately three times greater than that of the fresh one), and the available phosphorus level decreased sharply to 20.8 ppm. The total potassium content of the fresh was 4,200 ppm, while that of the mature one increased to 10,000 ppm. The available potassium content of the fresh one was 1,700 ppm, and that of the mature mixture decreased slightly to 1,300 ppm.

3.2 Bacteriological properties

The bacteriological characteristics of fresh and mature agricultural waste mixed with horse manure exhibited notable variations in bacterial populations between the two combinations, as illustrated in Table 2. The total viable heterotrophic bacterial population in the fresh combination was quantified to be 4.3 x 10^9 CFU/g, which increased to 6.8 x 10^5 CFU/g under mature conditions. The population of beneficial actinomycetes increased to 4 x10^3 CFU/g in the mature mixture, in contrast to the fresh mixture (1 x 10^2 CFU/g). Both mixtures contained almost the same number (<100) of Pseudomonas populations. Potentially pathogenic faecal coliform and streptococcal counts were much higher in the fresh (2 x 10^3 and 3.6 x 10^7, respectively) than in the mature mixture (<100 and 2 x 10^2, respectively).

Table ٢. Bacteriological characteristics of fresh and aged agricultural waste and horse manure mixtures under Egyptian field circumstances.

Parameter	Fresh mixture Count (CFU/g)	Mature mixture Count (CFU/g) (after 8 months)
Total viable heterotrophic bacteria	4.3 x 10^9	6.8 x 10^5
Actinomycetes	1 x 10^2	4 x 10^3
Pseudomonas	<100	<100
Faecal coliform	2 x 10^3	<100
Faecal Streptococcus	3.6 x 10^7	2 x 10^2

For quality assurance and quality control (QA/QC), table 3 displays the fully mature compost analysis results after one year of processing before giving permission to be applied to Egyptian fields. Notable increases were apparent in the following parameters: the total phosphorus increased from 1,064 ppm to 7,300 ppm, organic carbon increased by 11%, and total nitrogen increased from 5,320 ppm to 9,200 ppm. These enhancements demonstrate how well the maturation process improves compost quality. The compost did not contain dangerous pathogens such as coliform, *E. coli*, *Salmonella*, *Shigella*, or Nematoda. Nematoda was no longer present when the maturation period ended, despite being present in trace amounts at the 4-month mark.

Table ٣. Chemical and microbiological analyses of mature compost (after 12 months of processing) before its application in Egyptian agriculture fields (QA/QC).

a. Chemical analyses							
pH	Electrical conductivity (EC)	Total nitrogen	Organic carbon	Organic matter	C/N ratio	Total phosphorous	Total potassium
7.36	1.68	0. 92% (9,200 ppm)	30.2%	17.5%	1:19	0.73% (7,300 ppm)	0.36% (3,600 ppm)
b. Microbiological analysis							
Coliform group	*E. coli*	*Salmonella* spp	*Shigella* spp	Nematoda			
Nul	Nul	Free	Free	Free			

3.3 Seasonal abundance of *Phyllognathus excavatus* using light trap

Light trap data on the adult scarab beetle *Phyllognathus excavatus* (Fig. ١) revealed that this species was low from May to September, with the most significant number recorded in October and November, when it peaked. The species then disappeared for the winter months of December, January, and February and for part of the spring (March–April).

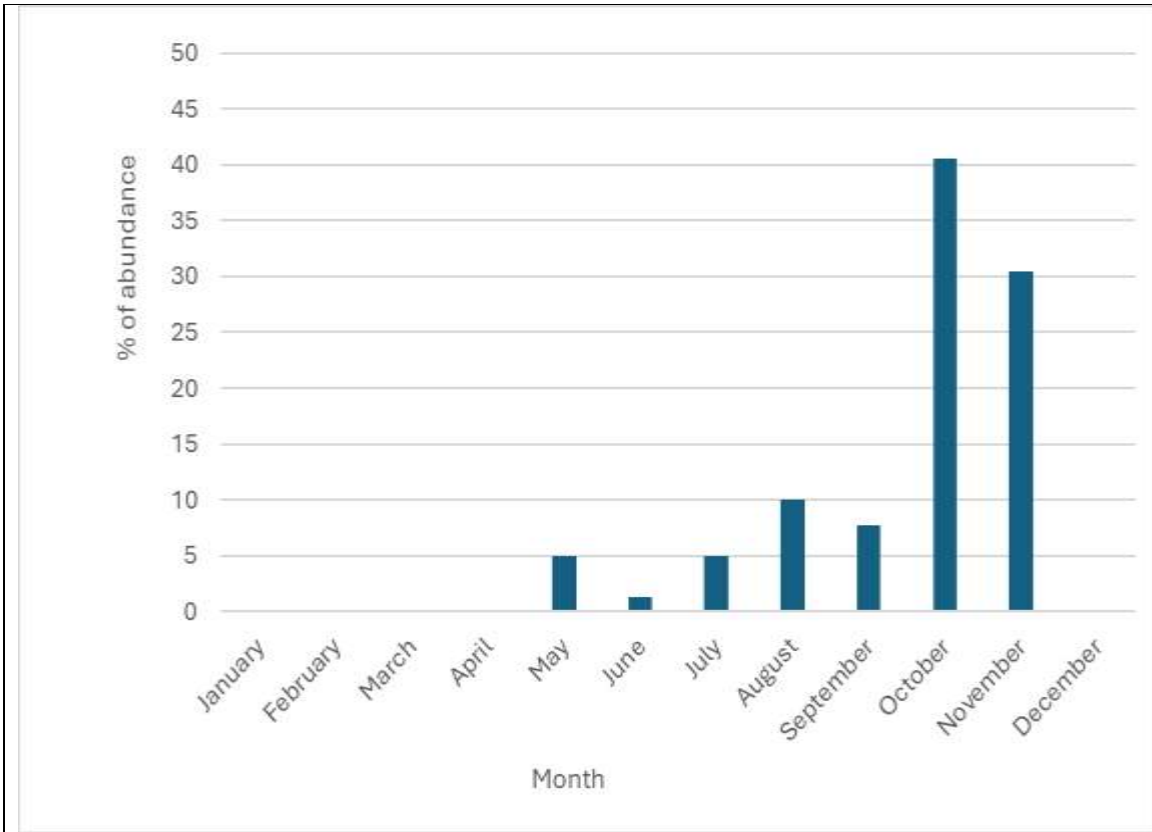

Figure 1: Seasonal abundance of adult scarab beetle (*Phyllognathus excavatus*) throughout a year, detected using a light trap.

3.٤ Faunal diversity in fresh and mature mixtures

The analysis of fresh and mature compost mixtures revealed notable disparities in the abundance and distribution of insects, other invertebrates, and reptiles in both mixtures; as shown in Fig. 2, a total of 23 different species were documented in both the fresh and mature mixtures, including 16 species of insects from different taxonomic orders (Zygentoma, Dermaptera, Dictyoptera, Orthoptera, Diptera, Coleoptera, Hymenoptera) as well as five species of other invertebrates (including woodlice, centipedes, earthworms and spiders) and two species of reptiles, namely, the flower-pot snake and the Turkish gecko.

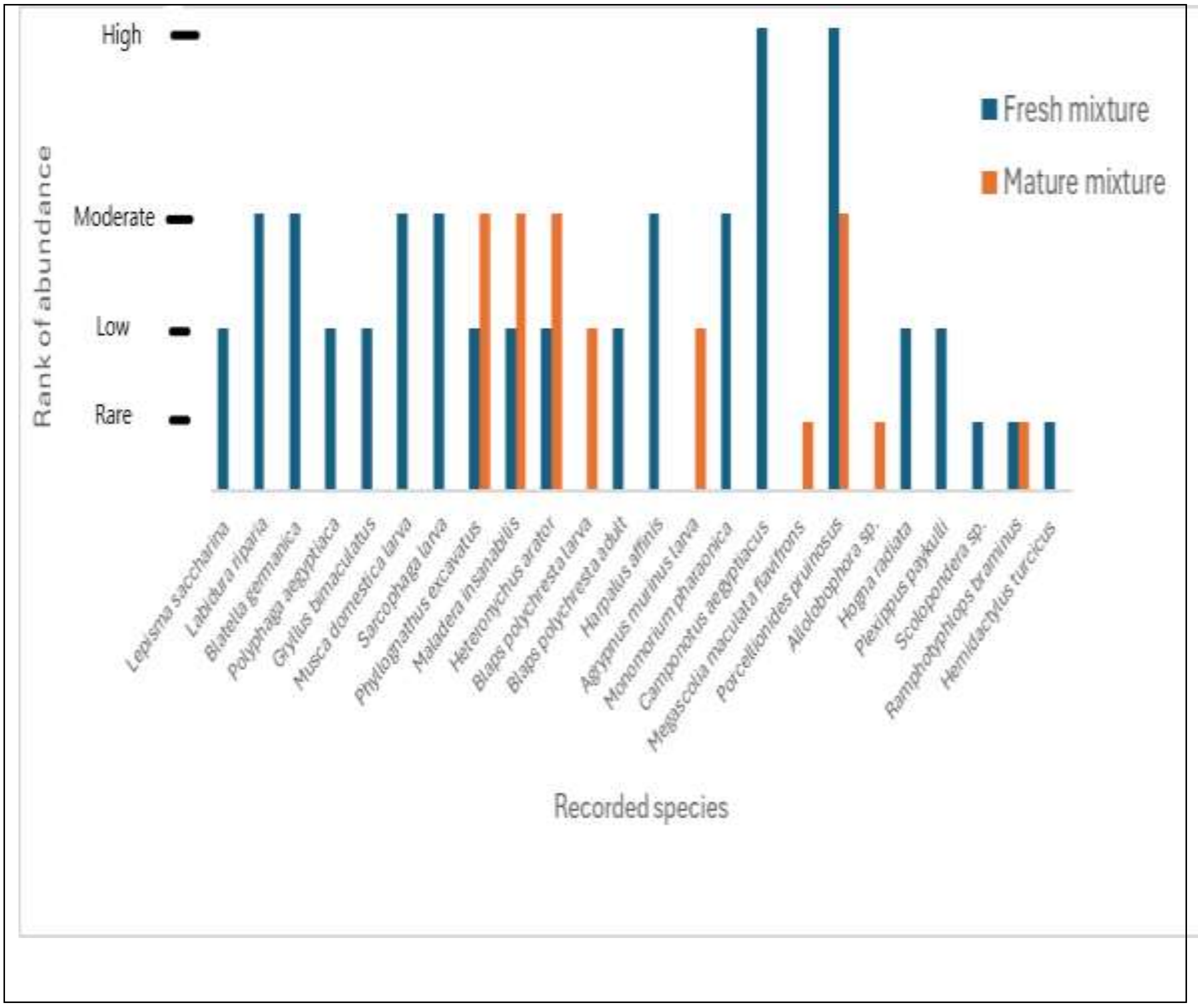

Figure 2: The species diversity in the fresh (blue) and mature (red) horse manure and agricultural waste mixture under Egyptian field conditions. High = ≥ 50 individuals/m^3. Moderate = 10–49 individuals/m^3. Low = 4–9 individuals/m^3. Rare = ≤ 3 individuals/m^3

Twenty species were recorded in the fresh mixture (an unprocessed combination of horse manure and agricultural waste). The woodlice *Porcellionides pruinosus* and the carpenter ant *Camponotus aegyptiacus* were particularly common (high presence), whereas the ground beetle *Harpalus affinis*, the German cockroach *Blatella germanica*, the earwig *Labidura riparia*, the pharaoh ant *Monomorium pharaonica*, the larva of the house fly *Musca domestica* and the larva of the flesh fly *Sarcophaga* sp. were recorded as moderately abundant. Other species, including the silverfish *Lepisma saccharina*, the

Egyptian cockroach *Polyphaga aegyptiaca*, the two-spotted cricket *Gryllus bimaculatus*, the scarab beetles *Phyllognathus excavatus*, *Maladera insanabilis*, and *Heteronychus arator*, the adult Egyptian beetle *Blaps polychresta*, the wolf spider *Hogna radiata* and the jumping spider *Plexippus paykulli*, were present in relatively small quantities (low presence). The millipede *Scolopendra* sp., the flower-pot blind snake *Ramphotyphlops braminus*, and the Mediterranean house gecko *Hemidactylus turcicus* were rarely encountered; only one individual was observed (rare presence). Four species that were not present, including the larva of the Egyptian beetle *Blaps polychresta*, the larva of the click beetle *Harpalus affinis*, the scoliid wasp *Megascolia maculata flavifrons*, and the earthworm *Allolobophora* sp., were recorded only in the mature mixture (compost).

Only nine species were identified in the mature mixture (compost). The scarab beetles (*Phyllognathus excavatus*, *Maladera insanabilis*, and *Heteronychus arator*) and woodlice (*Porcellionides pruinosus*) were moderately abundant. The larvae of the Egyptian beetle *Blaps polychresta* and the larvae of the click beetle *Agrypnus murinus* were observed in small numbers (low presence). Flower-pot blind snakes (*Ramphotyphlops braminus*), female scoliids (*Megascolia maculata flavifrons*), and earthworms (*Allolobophora* sp.) were rarely observed in the sample (only one individual was observed).

DISCUSSION

For the first time, this study revealed significant changes in the chemical, bacteriological, and animal diversity of fresh and mature compost mixtures from agricultural waste and horse manure under Egyptian field conditions. These changes highlight the roles of microbial activity, nutrient dynamics, and animal fauna in compost maturation. High salinity can harm many soil microorganisms because some are sensitive to salt, whereas others can tolerate it. In this study, the salinities measured for both samples (2.1 ds/m for the fresh material and 2.4 ds/m for mature compost) are generally favorable for microbial activity. Richard [12] reported that elevated salt concentrations can lead to nutritional imbalances by affecting the ability of plant roots to absorb essential nutrients. The increase in electrical conductivity from 2.14 ds/m to 2.4 ds/m in the mature mixture is due to the concentration of soluble salts during decomposition. It is consistent with the findings of Bernal et al. [17], who also reported an increase in electrical conductivity due to the degradation of organic materials. The decrease in pH from 8.2 to 7.15 reflects a neutralization process essential for improving the suitability of the mixture for plant growth. This pattern was noted in compost research conducted by de Bertoldi et al. [18], who reported that the pH tends to neutralize as organic acids break down during the composting process. Under acidic conditions (pH values below 7), essential nutrients such as calcium and phosphorus are less accessible. According to Page [10 & 11], too acidic soils can harm certain plants by increasing the availability of toxic elements such as aluminum. The soil pH significantly influences microorganism diversity and activity. The pH range of 6-7 is near neutral and optimal for the metabolic activities of most microorganisms, making it the most favorable environment for soil biological activity. The substantial decrease in organic matter and carbon also corroborates the findings of Niazi et al. [19] and Tiquia et al. [20], both of which identified a decrease in these components as indicators of compost maturity and stability.

Moreover, organic matter is essential for soil health, supplying vital nutrients to plants and promoting microbial activity. It contributes to soil structure, nutrient levels, and water retention. In this study, the organic matter content was 34.86% in fresh manure and 19% in composted manure, reflecting effective decomposition by microbes [21].

Soil organic matter consists of living and decomposing elements, including plant roots and microorganisms, at various stages of degradation. They are generated when soil organisms break down organic (carbon-based) substances, including compost and organic fertilizers. Although these elements constitute only 2–8% of soil, they are critical for soil fertility and plant growth. The decrease in total nitrogen and increase in available nitrogen observed in this study (from 19,600 ppm to 5,320 ppm and 112 ppm to 224 ppm, respectively) indicate nitrogen mineralization, similar to that reported by Biyada et al. [22] and Sánchez-Monedero et al. [23], who highlighted the importance of this process in the production of nutrient-rich compost.

Nitrogen is an essential nutrient for plant growth and development and is a key component of numerous plant structures. It is crucial for chlorophyll, enzymes, and proteins and is needed in more significant amounts than most other nutrients. Nitrogen promotes root development, overall plant growth, and the absorption of other nutrients. Except for legumes, which can fix atmospheric nitrogen (N2), plants generally respond quickly to nitrogen applications. In natural ecosystems, nitrogen cycles from soil to plants and back through microbial biomass, ensuring a balance between nitrogen inflow and loss. However, in agricultural systems, this cycle is often disrupted by removing large amounts of nitrogen from harvested crops. Therefore, nitrogen fertilizer application is critical for maintaining or increasing soil productivity. Over 50 years, increased use and better management of nitrogen fertilizers have significantly improved global food production. The increase in total phosphorus alongside a decrease in accessible phosphorus aligns with the findings of Raviv et al. [24], who noted that while phosphorus stabilizes during composting, it continues to be advantageous for long-term soil fertility. Similarly, the findings regarding potassium in this study, which indicate a rise in total potassium levels and a modest decrease in accessible potassium, are corroborated by Barker's research [25], which reported that potassium was released as compost matured and converted into an insoluble potassium form.

With the decline in total viable heterotrophic bacteria and the increase in actinomycetes as compost maturation progresses, the overall microbial activity decreases as decomposition approaches completion. This phenomenon was elucidated and thoroughly recorded by Insam and de Bertoldi [26], and Beffa et al. [27] reported similar microbial dynamics during composting. Reducing faecal coliform and faecal streptococcal populations further increases the safety of mature compost for agricultural use, as confirmed by Strom [28], who reported that proper composting reduces the presence of pathogenic microorganisms.

Under Egyptian field conditions, our analysis revealed that one year is the ideal maturation time for horse manure combined with dry and green agricultural residues. Research has indicated that increases in nitrogen, carbon, phosphorus, and the carbon-to-nitrogen ratio (1:19) render this time frame adequate for compost production with high-quality chemical properties. Pathogens must not be present in compost, as compost containing these pathogens can harm health. Our data revealed the absence of various pathogens, including coliform bacteria, *E. coli*, *Salmonella*, *Shigella*, and nematodes The implications of faecal coliforms in compost for soil, water, and crop health are highlighted by Rai and Suthar [29] as being of utmost importance. Faecal contamination is indicated by faecal coliform bacteria, which can degrade soil quality by introducing pathogenic microorganisms that upset the natural microbial balance. This pollution may cause the soil to become less fertile and unable to sustain healthy plant growth.

Pathogen uptake can negatively impact crop yield and quality, which increases the risk of foodborne illnesses in crops grown in contaminated soil. Murphy et al. [30] highlighted the significant dangers of *E. coli* contamination in compost. Their findings underscore that the existence of *E. coli*, particularly pathogenic strains such as *E. coli* O157, may result in severe gastrointestinal diseases if they contaminate crops. This pathogen poses a significant health risk to consumers, as it can spread from contaminated compost to edible plants. The investigation revealed that foodborne outbreaks can occur if crops grown in compost contaminated with *E. coli* are consumed. Ávila-Quezada et al. [31] reported that *Salmonella* spp. can contaminate plant tissues in compost, posing severe health risks to consumers who consume contaminated fruits and vegetables. Abawi and Widmer [32] asserted that nematodes contribute to increased plant diseases and diminished crop output. This study highlights the damaging effects of nematodes on vegetable crops, which can lead to severe damage and reduced yields. Therefore, eliminating nematodes by the end of the compost maturation period is beneficial, as it reduces the risk of plant damage and increases plant productivity and health.

Crowther et al. [33] emphasized the role of soil invertebrates in regulating microbial communities, improving ecosystem functions, and accelerating decomposition. Allegro and Sciaky [34] proposed using beetles as soil and environmental health bioindicators. The recorded scarab beetles (*Phyllognathus excavatus*, *Maladera insanabilis*, and *Heteronychus arator*) play a role in nutrient utilization and the breakdown of organic matter. These beetles are crucial for decomposing organic matter and enhancing soil fertility and structure, especially in agricultural environments. Owing to their capacity to promote the breakdown of vegetal matter and manure, they are essential for soil carbon and nitrogen cycling and promote healthy plant growth. Additionally, their tunnels store nitrogen and hold water, resulting in greater plant growth due to increased soil moisture and lower erosion rates [35]. The occurrence of the adult carabid beetle in fresh organic mixes and its absence in more mature compost is consistent with its ecological role in feeding on available foods. The occurrence of *Blaps polychresta* in the fresh mixture, especially in its adult form, underscores the species' contribution to the initial phases of organic matter decomposition. Adult beetles were noted to be more prevalent in the fresh mixture. However, they were observed in low numbers, which is consistent with their behavior as surface feeders searching for decaying organic material to consume. *Blaps polychresta* larvae were present in the mature mixture, although at low abundance, and adults were not detected. This finding echoes the work of Slade et al. [9], which highlighted that beetle larvae could thrive in more stable decomposed materials because their developmental stage is more suitable for environments where organic material is more processed. This shift in beetle activity and presence between different decomposition stages highlights the role of beetles in different stages of the decomposition process and their adaptive strategies to utilize available resources. Cockroaches (*Blatella germanica* and *Polyphaga aegyptiaca*) find sufficient food from spoiled vegetables and fruits and suitable living conditions in fresh mixtures rather than mature compost. McIlveen [36] reported that cockroaches become less common in composting systems as they mature, largely because of environmental conditions and changes in nutrient availability. The presence of *Labidura riparia* in the fresh mixture highlights the insect's ecological preference for moist environments rich in decomposing organic material and prey availability. Maczey et al. [37] reported that earwigs thrive in early-stage compost with high organic content, but their numbers decrease as the material becomes more compact and less nutrient-rich. The occurrence of ant species (*Monomorium pharaonica* and *Camponotus aegyptiacus*) in the fresh mixture and their lack of mature compost indicate their ecological preferences as omnivores. They flourish in settings characterized by elevated organic matter, wetness, and accessible food resources, such as those found in fresh compost mixes. However, as the compost matures, the habitat becomes less suitable for the species due to the lower moisture content and lower availability of decomposing organic material, resulting in the ants no longer being present in the mature compost. The female scoliid wasp from the order Hymenoptera, *Megascolia maculata flavifrons*, was exceptionally unexpected. The female of this large wasp entered the ripe compost and moved quickly within the compost pile. She seemed to be looking for large scarab beetles because we recorded many larvae. This species, documented in southern Spain as a parasitic female, can be found between decaying wood and tree stumps when large, plump rhinoceros beetle larvae (*Oryctytes nasicornis*) are identified [38]. Abu-Rayyan et al. [39] studied housefly larvae, and Szpila et al. [40] studied fleshfly larvae and reported that these flies are effective decomposers of decaying material and contribute significantly to nutrient cycling in compost environments. The immature stage of both species was recorded in a fresh mixture of horse manure and agricultural waste. Silverfish were detected in the fresh mixture. Manno et al. [41] reported that this species feeds on various organic materials, including cellulose and starch. Kozlovskaja and Striganova [42] reported that isopods belong to the soil saprophagous arthropods, which are involved mainly in carbon cycling and stimulate the mineralization of plant residues in the soil. They form symbiotic relationships with microorganisms that can break down nitrogen-free compounds and thus regulate microbial activity in the soil. *Porcellionides pruinosus* is common in fresh and mature mixtures. Oliveira et al. [43] reported that this species harbors common members of the soil microbiota, bacterial symbionts, bacteria associated with host metabolic/ecological traits, and bacterial aetiological agents.

The recorded species *Scolopendra* sp. is an effective predator in compost ecosystems and helps control relatively small arthropods and maintain the ecological balance. Lewis and Daszak [44] reported that millipedes are active hunters who rely on moist environments for survival. The same behavior is observed in spiders, especially the wolf spider (*Hogna radiata*) and the jumping spider (*Plexippus paykulli*), which is essential in controlling the population of small invertebrates in their habitat. The data also revealed the presence of an earthworm species (*Allolobophora* sp.) in minimal quantities within the soil of the mature compost, with no observations in the fresh mixture. The interplay between earthworms and bacteria in manure introduces an additional layer of complexity to the microbial ecosystem. Earthworms act as natural mixers, physically breaking down manure and creating a more aerated environment, enhancing aerobic nitrogen-fixing bacteria's activity, enabling them to flourish and contribute more efficiently to nitrogen fixation and overall nutrient cycling dynamics. Henderson and Powell [45] noted that flower-pot blind snakes are typically located in loose soil and organic material and feed on ants and termites. The presence of this species in both fresh and mature compost mixes suggests that it plays a minimal but essential role in controlling small insects, particularly ant species. The documented species of Turkish gecko, *Hemidactylus turcicus*, likely prey on small insects attracted to decomposing organic matter. As the compost matures and the insect population decreases, the gecko's food source decreases and is absent from the mature mixture.

To secure the quality assurance and quality control of the compost (QA/QC), the Ministry of Agriculture recommends using the compost since the product meets the conditions and specifications that make it suitable for use and highly efficient for Egyptian fields. The recommendation is based on the following parameters: the compost show full maturation, good quality and free from pathogens and nematodes; rich in organic matter; salinity does not exceed 10 mmol/cm, pH value does not exceed 7.5; carbon to nitrogen ratio (C:N) less than 1:20, NPK content within acceptable range.

CONCLUSION

The accumulation of fresh equine excrement combined with green and dry agricultural residues predominantly attracts a consortium of soil-dwelling organisms that facilitate the decomposition of these materials, including scarab beetles, woodlice, earthworms, immature fly stages, silverfish, cockroaches, crickets and ant nests. Due to the availability of various species within the heap, along with nutritional elements such as dung, plant and animal fibers, and decaying vegetables and fruits, the transformation of these agricultural wastes into compost is ensured. This process occurs in the presence of different microorganisms, including bacteria and fungi, under suitable environmental conditions. The heap attracted a variety of omnivores and predators, including ground beetle larvae, click beetle larvae, earwigs, spiders, centipedes, flower-pot blind snakes (feed on ants), and geckos. This diverse group contributes to the overall biodiversity of the agroecosystem.

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