International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 26-11-2025, Accepted: 25-12-2025, Published: 09-01-2026
Volume 11, Issue 1, 2026, Page No. 28-34

Evaluation of frass expelled by African Migratory Locust and Desert Locust in both summer and winter seasons as a byproduct for sustainable fertilizer use

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Abstract

Globally, the most required issues are sustainable development and growing green to protect our limited resources. The species of *Locusta migratoria* and *Schistocerca gregaria* are thought to be among the oldest living organisms on Earth. Because grasshoppers have substantially lower cultivation and production costs and a lot reduced environmental effect (mostly greenhouse gas emissions and waste generation—zero waste), they are one of the long-term sustainable solutions. This study highlighted the evaluation of frass expelled by locusts as a byproduct for fertilizer use, as it displays a favorable solution for the effective organic wastes in reaction to the desire of consumers for sustainable fertilizer.

Keywords: *Locusta migratoria*, *Schistocerca gregaria*, feces, mineral

Introduction

The two biggest issues that the current agricultural system must address are feeding the growing global population and reducing climate change (AR4 Climate Change 2007: Mitigation of Climate Change — IPCC [WWW Document], n.d.). According to estimation, there will be 10 billion people in 2050 to feed in the context of soil degradation (Gomiero, 2016) [15] the food-energy-environment trilemma of land use (Tilman *et al*., 2009) [31]. As a result, it is doubtful that food production will be enhanced by using new land or adding more nutrients because plants have a critical absorption limit (Lemaire *et al*., 2023).

The efficiency of fertilizer usage in agricultural systems must be increased immediately, and also biogeochemical cycles must be managed sustainably (Penuelas *et al*., 2023) [24].

This includes the research and implementation of current biotechnological techniques, such as plant growth-promoting rhizobacteria (PGPR) and diazotrophic N2-fixing bacteria, as alternatives to conventional fertilization.Sustainable fertilizers are designed to nourish plants while minimizing environmental harm, contrasting with conventional fertilizers that often have negative ecological impacts.As the need for alternate protein sources grows, it is anticipated that insect output will increase over the coming years, which should result in large amounts of frass (Houben *et al*., 2021) [16]. An insect feces, or “frass” as it is scientifically called, is the most prevalent by-product of insect production. Frass should be used to uphold a circular economy since it is produced in larger quantities than the real insect products (Nyanzira *et al*., 2023) [21]. The chitin-rich exoskeleton pieces from the insect and the uneaten feed substrate remnants seen in frass are thought to be able to activate plant immune responses, potentially increasing the plant's resistance to pests and diseases (Quilliam *et al*., 2020) [26]. The amount of frass that is produced can often range from 80 to 95%, depending on the type of insect and its food (Poveda *et al*., 2019) [23]. Large amounts of frass are produced by the insect and are a particularly significant byproduct. It appears as a collection of exuviae, feces, and unconsumed substrate. This product is highly ideal for use as fertilizer because it includes substantial amounts of nutrients and helpful microorganisms (Beesigamukama *et al*., 2023) [7]. There are still few studies on the use of frass fertilizer obtained from edible and commercial insects as an organic fertilizer (Beesigamukama *et al*., 2022) [6]. Although the insects' diet mostly determines the nutritional profile of frass, it can generally be described as having a narrow carbon (C) to N ratio, a high organic matter content, and an abundance of nutrients like nitrogen (N), phosphorus (P), and potassium (K) (Watson *et al*., 2021) [33].One of the most notable features of frass's potential application as fertilizer is its ability to supply nitrogen (Poveda, 2021) [22, 25].

According to a study by Shin *et al*. (2019) [30], the composition of chitosan derived from mealworms (*Tenebrio molitor* L.) was extremely comparable to that of commercial chitosan, exhibiting the ability to suppress the development of bacteria such *Escherichia coli*, *Listeria monocytogenes*, and *Bacillus cereus*.Furthermore, as agricultural techniques advance toward greater circularity, it is expected that their prices would grow due to the increased demand for these by-products (Niyonsaba *et al*., 2023) [20].The anticipated expansion of large-scale insect production to fulfill the demand for alternative protein sources (Derrien and Boccuni, 2018) [11] is projected to generate substantial volumes of frass (Poveda, 2021) [22, 25]. Owing to its elevated concentrations of nitrogen (N), phosphorus (P), and potassium (K), along with the possible existence of advantageous microorganisms (Poveda *et al*., 2019) [23], the use of frass as a fertilizer may contribute to the diminution of agrochemical usage. For instance, frass from the black soldier fly (*Hermetia illucens* L.) was effectively utilized as an organic fertilizer to enhance maize growth (Beesigamukama *et al*., 2020; Gärttling *et al*., 2020) [5, 13]. Moreover, frass derived from *T. molitor* demonstrated significant potential as a partial or complete alternative to mineral NPK fertilizers for barley cultivation (Houben *et al*., 2020), while also enhancing soil microbial (Poveda *et al*., 2019) [23] and earthworm activity (Dulaurent *et al*., 2020) [12]. More research on the fertilizer potential of frasses is necessary due to the ongoing up scaling of the insect industry (Berggren *et al*., 2019) [8]. For many years, locusts have been viewed only in a negative light, they are responsible for devastating crop losses, and they also play an important role in nutrient cycling. Due to the high concentration of nutrients in their bodies and frass, combined with the ability to disperse over long distances over time, locusts are important for the redistribution of nutrients across regions, often in arid nutrient-poor areas. This takes place among many locust and grasshopper species around the world (Kietzka *et al*., 2021) [18]. The International Platform of Insects for Food and Feed (IPIFF 2021) [17] defines insect frass as a combination of farmed insect excrement, feeding substrate, dead eggs, and parts of farmed insects, with a maximum volume and weight content of 5% and 3%, respectively, of dead farmed insects. Insect frass is a beneficial byproduct that may be utilized as fertilizer (Poveda, 2021) [22, 25]. The addition of frass created from mass-produced insects to soil has been found to increase the growth of certain vegetables (Anyega *et al*., 2021; Chiam *et al*., 2021) [1, 10], and promote nitrogen mineralization and soil microbial activity (Beesigamukama *et al*., 2021; Gebremikael *et al*., 2022) [4, 14]. The substrate used to raise insects can have an impact on the chemical composition of frass. For example, studies on the black soldier fly have revealed significant variations in the frass's chemical composition depending on the substrate utilized for rearing (Arabzadeh *et al*., 2022) [3]. Yakti *et al*., 2024 [34] found the frass produced by desert locust *S. gregaria* nymphs, which was collected daily for later analysis, originated from nymphs raised on two different diets: tomato leaves and wheatgrass. The locusts fed on wheatgrass exhibited better growth compared to those fed on tomato leaves. The analysis revealed significant differences in the concentrations of various nutrients in the frass, including boron (B), calcium (Ca), copper (Cu), potassium (K), magnesium (Mg), molybdenum (Mo), sodium (Na), phosphorus (P), sulfur (S), zinc (Zn), and nitrogen (N), depending on the type of plant they were fed. Specifically, the frass from locusts fed wheatgrass contained lower levels of molybdenum (Mo) and phosphorus (P), but higher levels of boron (B), calcium (Ca), copper (Cu), potassium (K), magnesium (Mg), manganese (Mn), sodium (Na), sulfur (S), zinc (Zn), and nitrogen (N). Notably, none of the samples analyzed contained cobalt (Co) compared to those fed on tomato leaves.

A significant amount of frass is produced as a byproduct of raising insects for food and feed, which gets collected as material waste (Poveda *et al*., 2019) [23]. According to Chavez and Uchanski (2020) [9], frass is a solid insect waste material that has been transformed into a microbially rich substance by insect food digestion, leading to a higher product in organic matter. Therefore, it is crucial to utilize all of an insect's components, including their frass, as an organic fertilizer in order to support a circular economy and consider zero waste. Insect frass is a mixture of uneaten feeds, faeces, and exuviae or exoskeletons produced during the molting stage. These substrates can be utilized as organic fertilizer in crop production, which will increase crop output (Anyega *et al*., 2021) [1]. It's a relatively recent idea to use locust frass as an organic fertilizer. No research has been done on the performance of degraded locust frass. Therefore, the current study aimed to determine the evaluation of frass expelled by locusts in both summer and winter seasons as a byproduct for fertilizer use. Van der Fels-Klerx *et al*. (2020) [32] describe the concepts of a circular bioeconomy, in which the waste "a fertilizer known as frass" from raising black soldier fly larvae *Hermetia illucens* is used as a resource for another, resulting in two beneficial outputs. Frass has the potential to replace conventional N fertilizers and mitigate the global warming risk associated with the use of any conventional N fertilizer (Schmitt and de Vries, 2020) [29]. In order to maximize the sustainable use of locust's frass as a substitute for mineral and chemical fertilizers, the current study sought to understand the fertilizer value of the material. Insect output is predicted to increase significantly over the next years, due of the growing need for alternate protein sources, utilizing all of the insect's components, including their frass, is essential given the "zero waste" philosophy and the necessity to support the circular economy. According to this study, locust frass has a lot of promise for usage as a whole or partial replacement for mineral NPK fertilizer.

Materials and Methods

Experimental Insect

The feces of both locusts (Orthoptera: Acrididae) African migratory locust *L. migratoria* and desert locust *S. gregaria* (Frosk.) were originated by a lot of gregarious nymphs obtained from Locust and Grasshoppers Research Department, Plant Protection Research Institute, Agricultural Research Center, Doqqi, Giza. Insects were reared in wooden formed cages measuring: 60 cm length x 60 cm Width x 70 cm height. Three sides of the cage were made of wood and glass and the fourth side and top was with a wire gauze tope. The front side of the cage was provided with a small door to facilitate daily routine work and maintenance of the insects. The bottom was furnished with a sandy layer of 15 cm depth and with 10-15% humidity to be suitable for egg laying. An electric bulb (100 watt in winter 50 watt in summer) was adjusted to maintain a continuous photoperiod of 12 L: 12 D in each cage as well as in order to maintain an ambient temperature of 32±2°C. The insects were reared and handled under the crowded conditions. Adults were placed in each cage for egg laying. Care was seriously taken to clean these cages at regular intervals and the sand was sterilized in drying oven (at 140°C for 24 hours) to avoid contamination with any pathogenic microorganisms. African migratory locust *L. migratoria* fed on wheat *Triticum aestivum* in winter and on maize *Zea mays* in summer, while fresh clean leaves of berseem Egyptian clover, *Trifolium alexandrinum*, influenced survival and development of the desert locust *S. gregaria* in winter, and the leaves of leguminous plant *Sesbania aegyptiaca*, in summer, were used as a food for insects; following the methods described by Robert *et al*. (2002) [27].

Frass Collection

Locusts excrete feces through the anal opening, typically in the form of small pellets or fine granules. For daily sample collections by sieve the soil, frass was obtained from both locusts of (desert locust and African migratory locust) separately. The insects used for feces production were nymphs and adults of locusts of both sexes. The feces, dead locusts and food remains were removed and collected daily before introducing the freshly food in cages; by passing in different sieves, first sieved through a 1 mm mesh screen to separate pellets from to remove sand, then 1cm sieve to remove and separate large fragments food remains from the rest of the feces. Before the experiment, the samples were kept allowed to air dry at lab temperature, and then the feces were ground for chemical analysis. All assays were performed in triplicate.

The Estimation of Minerals Contents

Nitrogen (N), phosphorus (P), potassium (K), sodium (Na), iron (Fe), zinc (Zn), manganese (Mn), cobalt (Co), lead (Pb), nickel (Ni), and cadmium (Cd) concentrations were determined in dried samples; using Optima 2000 DV inductively coupled plasma spectrometer, (PerkinElmer). Concentrations were recorded based on calibration curves developed using inductively coupled plasma (ICP) (merk) standard in reference to A.O.A.C. 2023. All assays were performed in triplicate.

The physical and chemical properties of substrate

Water hold capacity % (W.H.C) is the amount of water present after the substrate in a container has been saturated and allowed to drain.

Water hold capacity % = ((FW- DW)/ VB) x 100

FW (fresh weight) = weight of substrate after stop draining

DW (dry weight) = dry weight of substrate after 24 hours at a temperature 80 – 90 oC.

The PH of the frass was evaluated using a 1:5 (w: v) double distilled water suspension of each potting mixture that had been mechanically agitated for 2 h and filtered through Whatman no.1 fillter paper (Inbar *et al*., 1993). With a conductance meter standardized with 0.01 and 0.1M KCl, the electrical conductivity of the same solution was measured.

Statistical analysis

Statistical analyses Software (SAS 1998) [28] program was adopted for collected data using

Results

This study's goal was to examine the possibility of applying frass as organic fertilizer.

Morphometry Quantitative Description of Fecal Pellet

African migratory locust *L. migratoria* fed on maize and wheat in summer and winter, respectively; while *S. gregaria* fed on *S. aegyptiaca* and berseem in summer and winter, respectively, depending on dietary regulation the feces (Fig. 1) will be distinguishable, which is the solid waste excreted by locusts, differs from frass, which refers to feces in addition to remaining food and the cuticle exoskeleton of insects. The appearance of locust feces: The texture of locust feces is often dry and typically small and granulated, taking the form of tiny pellets or fine granules that are spherical to oval in shape, with sizes ranging from 1 to 12 millimeters in length. They are generally cylindrical with sharp ends. Depending on the locust's size, age, and dietary regulation, the shape can vary, with pellets or granules differing by the age of the locusts, as well as the species and diet of the plant material ingested. The feces consist of undigested plant material, and the surface is smooth to slightly textured, exhibiting tiny irregularities caused by pressure during excretion. They are comparatively desiccated due to water reabsorption in the rectum before evacuation. However, the odor of locust feces: Locust feces are generally odorless or have a mild earthy smell. Also, the color of locust feces; The color can vary from light yellow or brown, as seen in *L. migratoria*, to dark brown or black, as in *S. gregaria*, reflecting the plants that locusts consume. When locusts eat more colorful vegetation, the feces may take on different hues.

Fig 1: Comparative morphological characterization patterns of different fecal pellets of: An African migratory locust (summer feeding), B Desert locust (summer feeding), C African migratory locust (winter feeding), D Desert locust (winter feeding). Dash =1 cm

Composition of Insect Frass

physical, chemical properties and mineral composition and potential uses of African migratory locust *L. migratoria* and Desert locust *S. gregaria* frass depend not only on the kind of insect that it comes from; but the feeding of these in summer and winter.

Physical and chemical properties of frass from the African migratory locust (*L. migratoria*) and the desert locust (*S. gregaria*) during summer and winter feeding were showen in table (1). Frass of African migratory locust with winter feeding gave the highest values of EC while the increasing of PH was resulted in frass of Desert locust with winter feeding. Regarding to physical properties the obtained data indicated that the increase of water hold capacity (W.H.C) resulted in frass of desert locust with summer feeding while the highest organic matter (OM%) was found in frass of african migratory locust with winter feeding. The highest values of organic carbon (OC%) and ash were recorded in frass of desert locust with frass of winter feeding.

Table 1: Physical and chemical parameters of frass from the African migratory locust (*L. migratoria*) and the desert locust (*S. gregaria*) during summer and winter feeding

Parameters	Frass of summer feeding		Frass of winter feeding	
	L. migratoria	***S. gregaria***	***L. migratoria***	***S. gregaria***
EC ds/m	7.79	13.88	16.02	15.6
PH	5.77	5.9	6.06	7.23
W.H.C%	56.8	62.2	59.3	60.4
OM%	65.5	72.5	73.8	53.8
OC%	37.5	42.15	42.91	46.2
Ash%	35.5	27.5	26.24	46.2

EC (Electrical Conductivity) PH (Potential Hydrogen) Water hold capacity (W.H.C%) Organic Matter (OM%) Organic Carbon (OC%).

Table 2: Comparison of nutritional content in frass of the African migratory locust (*L. migratoria*) and the desert locust (*S. gregaria*) based on dry matter from summer and winter feeding

Nutrients (%)	Frass of summer feeding		Frass of winter feeding	
	L. migratoria	***S. gregaria***	***L. migratoria***	***S. gregaria***
N%	0.8^{ab}	0.73^{b}	0.66^{b}	0.98^{a}
P%	0.4^{a}	0.22^{b}	0.5^{a}	0.38^{ab}
K%	2.55^{a}	3.33^{a}	3.56^{a}	3.02^{a}
Na%	1.51^{d}	2.01^{b}	2.16^{a}	1.87^{c}

Means followed by the same letter are not significantly different

Data presented in Table 2, which outlines the nutrient content (Nitrogen, Phosphorus, Potassium, and Sodium) found in the frass of two significant locust species: the African migratory locust (*L. migratoria*) and the Desert Locust (*S. gregaria*). The frass of Desert locust during winter feeding (0.98%) exhibits the highest nitrogen content in its frass, significantly higher than all other groups, indicating a potentially higher nitrogen intake or less efficient nitrogen utilization during this period. While nitrogen in the frass of African migratory locust in summer feeding, was (0.80%) and the frass of Desert locust in summer feeding was (0.73%) show similar nitrogen levels, which are generally lower than the Desert locust's winter frass. The frass of African migratory locust during winter feeding (0.50%) and frass of African migratory locust during summer feeding (0.40%) show the highest and statistically similar phosphorus levels, suggesting consistent phosphorus excretion regardless of season for this species also, the frass of Desert locust during winter feeding (0.38%) has comparable phosphorus content to the frass of African migratory locusts. All groups show statistically similar and high potassium levels, ranging from 2.55% a (frass of African migratory locust during summer feeding) to 3.56% a (frass of African migratory locust during winter feeding). The highest potassium content is observed in the frass of African migratory locust (during winter feeding, 3.56%), followed closely by the frass of Desert locust during summer feeding, (3.33%). The frass of African migratory locust during winter feeding (2.16%) exhibits the highest sodium content in its frass.

This document provides a detailed explanation of the data presented in Table 3, which outlines the micronutrient content (Iron, Zinc, Manganese, and Cobalt) found in the frass of two significant locust species: the African migratory locust (*L. migratoria*) and the Desert Locust (*S. gregaria*). The analysis differentiates between frass produced during summer and winter-feeding periods.

Table 3: Comparison of micronutrient content in frass of the African migratory locust (*L. migratoria*) and the desert locust (*S. gregaria*) based on dry matter from summer and winter feeding

Nutrients (mg kg-1)	Frass of summer feeding		Frass of winter feeding	
	L. migratoria	***S. gregaria***	***L. migratoria***	***S. gregaria***
Fe	2943^{a}	3151^{a}	765^{b}	2362^{ab}
Zn	91^{b}	73^{b}	85^{b}	121^{a}
Mn	97^{c}	142^{a}	130^{ab}	124^{b}
Co	61.1^{a}	66.32^{a}	72.3^{a}	46.35^{b}

Means followed by the same letter are not significantly different

The frass of Desert locust during summer feeding (3151 mg kg^{-1}) and the frass of African migratory locust during summer feeding (2943 mg kg^{-1}) showed the highest values with similar statistically in iron content. The frass of Desert locust during winter feeding (2362 mg kg^{-1}) has intermediate iron content, not significantly different from the frass in the summer groups but significantly higher than the frass of African migratory locust in winter feeding. The frass of Desert locust during winter feeding (121 mg kg^{-1}) shows the highest zinc content, significantly higher than all other groups. The frass of Desert locust during summer feeding (142 mg kg^{-1}) has the highest manganese content, significantly higher than other groups except for the frass of African migratory locust in winter although, the frass of African migratory locust during winter feeding (130 mg kg^{-1}) and frass of Desert locust during winter feeding (124 mg kg^{-1}) show comparable manganese levels, with the winter feeding of African migratory locust being statistically similar to the summer feeding of Desert locust's frass. The frass of African migratory locust during winter feeding (72.3 mg kg^{-1}), results Cobalt (Co) content without no significant with frass of Desert locust during summer feeding (66.3 mg kg^{-1}), and frass of African migratory locust during summer feeding (61.1 mg kg^{-1}) exhibit statistically similar and higher cobalt levels in their frass.

Table 4: Heavy metal elements content in frass of the African migratory locust (*L. migratoria*) and the desert locust (*S. gregaria*) based on dry matter from summer and winter feeding

Nutrients (mg kg-1)	Frass of summer feeding		Frass of winter feeding	
	L. migratoria	***S. gregaria***	***L. migratoria***	***S. gregaria***
lead Pb	1.60^{a}	1.70^{a}	1.90^{a}	2.50^{a}
Nickel Ni	38.9^{b}	48.8^{a}	44.3^{ab}	48.2^{ab}
Cadmium Cd	0.049^{a}	0.017^{b}	0.004^{c}	nd.

Means followed by the same letter are not significantly different

Lead (Pb) as the highest level in the frass of *S. gregaria* was 2.50 mg kg⁻¹ in the winter feeding. Regarding other heavy metals, the *S. gregaria* frass exhibited the highest Nickel (Ni) levels during summer feeding (48.8 mg kg⁻¹). In contrast, the *L. migratoria* showed the maximum Cadmium (Cd) concentration in its frass during summer feeding, measuring 0.049 mg kg⁻¹.

Discussion

potentially due to increased bioaccumulation from contaminated vegetation or reduced excretion rates during this period. The higher nitrogen content in winter feeding's frass of the Desert locust could be attributed to consumption of nitrogen-rich plant tissues available in arid winter environments or changes in digestive efficiency influenced by temperature or life cycle stage. Also, the variations in phosphorus content in frass can reflect the phosphorus availability in consumed plants. The lower phosphorus in summer frass of the Desert locust might imply a diet poorer in P during that season or more efficient absorption of P by the insect. The consistent potassium levels across all samples suggest that potassium is a significant component of the locusts' diet that passes through their digestive system, or that it is less efficiently absorbed by the insects compared to other macronutrients. The sodium levels in frass can be highly variable depending on the salinity of the environment and the plants consumed. Insect frass is not merely waste; it can play a significant role in nutrient cycling within ecosystems. It acts as an organic fertilizer, returning nutrients like nitrogen, phosphorus, and potassium back to the soil, which can then be reabsorbed by plants. The possible use of frass from the yellow mealworm *T. molitor* as fertilizer was the main topic of Nyanzira *et al*., 2023 [21] study; when the mineral content as nitrogen, phosphorus, and potassium of frass was examined, it was discovered to be 3.3%, 2.8%, and 2.3% respectively; these values were consistent with values published in literature, indicating that the frass can be used as a supplement or substitute for fertilizer. Also, Beesigamukama *et al*., 2021 [4]; Gebremikael *et al*., 2022 [14]; Van der Fels-Klerx *et al*. (2020) [32] agreement with this result. The large seasonal variation in iron content for the frass of African migratory locust could indicate a shift in diet from iron-rich plants in summer to iron-poor plants in winter, or changes in metabolic requirements for iron due to environmental stressors like cold. However, the higher zinc levels in winter frass for the Desert locust might be linked to consuming plants that accumulate more zinc in colder months, or a reduced physiological need for zinc during a less active period, leading to more being excreted. This results agreement with (Arabzadeh *et al*., 2022) [3]. Yakti *et al*., 2024 [3, 34]. The variability in manganese content could be due to the specific plant species consumed by the locusts in different seasons, as plants vary widely in their ability to accumulate manganese. Also, the lower cobalt levels in the winter frass of the Desert locust might suggest a diet poorer in cobalt during that season or more efficient absorption by the insect, potentially due to higher physiological demand in winter. The results of this study indicate that locust frass is rich in nutrients, including nitrogen, phosphorus, potassium, and heavy metals within acceptable ranges, making it a valuable organic fertilizer for plants. It can enhance soil fertility and promote healthy plant growth. Fresh locust frass typically has an odorless or mild earthy smell, but it can become more pungent as it decomposes, especially if it contains a high amount of nitrogen. The presence of lead in locust homogenates indicates environmental contamination. While the differences are not statistically significant across all groups, the trend towards higher lead in winter-feeding Desert locusts might suggest regional differences in environmental lead levels or dietary shifts to plants that accumulate more lead. The higher nickel accumulation in Desert locusts during summer compared to African migratory locusts in the same season could point to species-specific differences in nickel uptake or metabolism, or to dietary variations, with Desert locusts consuming plants richer in nickel. However, the general trend of decreasing cadmium levels from summer to winter for African migratory locusts, and the very low to undetectable levels in Desert locusts, highlights significant seasonal and species-specific differences in exposure or accumulation. Cadmium is known to accumulate in insect tissues and its presence often indicates environmental pollution. The presence and varying concentrations of heavy metals in locusts have important ecological and environmental implications. Locusts, as primary consumers, can accumulate heavy metals from the plants they eat. These metals can then be transferred up the food chain to predators (e.g., birds, reptiles, humans who might consume locusts in some cultures), leading to biomagnification and potential health risks for higher trophic levels. Environmental Monitoring: Locusts can serve as effective bio-indicators of heavy metal pollution in their habitats. Their wide distribution and dietary habits make them suitable organisms for monitoring environmental contamination, especially in agricultural areas or regions near industrial activities.

Conclusion

The results of this study indicate that locust frass is rich in nutrients, including nitrogen, phosphorus, potassium, and heavy metals within acceptable ranges, making it a valuable organic fertilizer for plants. It can enhance soil fertility and promote healthy plant growth. Fresh locust frass typically has an odorless or mild earthy smell, but it can become more pungent as it decomposes, especially if it contains a high amount of nitrogen. Overall, frass, as a byproduct of locusts, is an important contributor to soil health.

The chemical composition of the results on frass is also influenced by the locust diet, which must be taken consideration if insect frass is to be utilized as fertilizer. Although the prospect of using insect byproducts as an organic fertilizer is highly attractive, further study is necessary to fully realize it's potential. Further research is required to examine its chemical and biological characteristics, particularly the bacteria that are present in it to learn more about how insect frass affects plant development. Further research is necessary as the insect frass is still in its infancy.

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