

ORIGINAL RESEARCH ARTICLE

Impact of Municipal Solid Waste Compost on Soil Quality in Peri-Urban Farmlands of Katsina State, Nigeria

Aminu Zakariyau^{1*}  and Mansur Abdul Mohammed³ ¹Department of Social Studies, Isa Kaita College of Education, P.M.B, 5007, Dutsin-ma, Katsina State, Nigeria²Department of Geography, Bayero University, Kano, Nigeria

ABSTRACT

The increase in population led to a high demand for food, which, in turn, caused a decline in soil nutrients, particularly under unsustainable fertility management practices. Following increases in the cost of chemical fertilizer and the availability and accessibility of municipal solid waste compost (MSWC), farmers on Katsina peri-urban farmland resorted to MSWC as a fertility-improvement material. Therefore, this study aimed to evaluate the impacts of municipal solid waste compost on soil quality using the soil quality index (SQI). The study assessed levels of soil fertility parameters and evaluated the area's soil quality. Twenty (20) soil samples were collected from MSWC-amended and control locations at 0-15 cm depth. Samples were tested in the laboratory for soil quality parameters using standard procedures. The results were statistically analyzed using a t-test ($p=0.05$) and the soil quality index (SQI) model. The results show that the mean values of pH (7.61; 5.89) and Db (1.29; 1.45) were higher at the MSWC farm than at the control location. Significant differences were observed among all soil fertility parameters at 0.05, except OM and avl. P, Mg, and clay. The mean SQI values for MSWC-amended and control soils were 0.47 ± 0.15 and 0.42 ± 0.25 , respectively, indicating that MSWC application improved soil quality by approximately 10.64%. The amended soils were classified as having “high” soil quality, while the control soils remained within the “moderate” category. The study demonstrates that MSWC application significantly enhances soil fertility and overall soil quality, thereby supporting sustainable agricultural productivity and environmentally sound waste management practices in peri-urban agroecosystems.

ARTICLE HISTORY

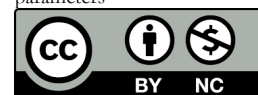
Received February 17, 2026

Accepted May 24, 2026

Published June 17, 2026

KEYWORDS

Municipal solid waste compost (MSWC), soil quality, quality parameters



© The Author(s). This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 License [creativecommons.org](https://creativecommons.org/licenses/by-nc/4.0/)

INTRODUCTION

Soil is a fundamental natural resource that performs essential ecological and agricultural functions, sustaining life on Earth. It serves as a reservoir and nutrient mediator, regulates water flow and availability, supports plant anchorage, and contributes significantly to carbon sequestration and environmental sustainability (Hong et al., 2021; Devi & Singh, 2023). However, increasing urbanization, industrialization, population growth, and technological advancement have intensified the generation of municipal solid waste (MSW) worldwide. According to Ferro (2021), global municipal solid waste generation has reached approximately 2.2 billion tonnes annually, averaging 1.42 kg/person/day. In many developing countries, improper waste disposal and declining soil fertility have become major environmental and agricultural concerns. Consequently, municipal solid waste compost (MSWC) has attracted considerable attention as a sustainable soil amendment due to its ability to improve soil structure, enhance nutrient availability, stimulate microbial activity, and reduce dependence on synthetic fertilizers (Manea et al., 2024).

The continuous cultivation of farmlands under low-input systems, especially in peri-urban regions of Nigeria, has contributed to nutrient depletion and deterioration of soil quality. Rising prices and limited access to inorganic fertilizers have encouraged farmers to adopt alternative fertility management strategies, such as MSWC. Organic amendments derived from municipal wastes can improve soil organic matter, enhance nutrient cycling, and increase soil productivity when properly managed. Biofertilizers and other biologically based soil amendments have also gained attention as sustainable alternatives to synthetic fertilizers because of their capacity to improve nutrient availability and crop performance. Isiya and Salisu (2024) reported the successful production of biofertilizer using phosphate-solubilizing *Pseudomonas* spp. isolated from rhizosphere soils in Katsina State, while Ibrahim et al. (2024) highlighted the growing importance of biofertilizers as environmentally friendly alternatives to chemical fertilizers in sustainable agricultural systems. Previous studies have shown that compost application can improve nutrient uptake efficiency and soil fertility status

Correspondence: Aminu Zakariyau. Department of Social Studies, Isa Kaita College of Education, P.M.B, 5007, Dutsin-ma, Katsina State, Nigeria. ✉ zaminu2020@gmail.com.

How to cite: Zakariyau, A., & Mansur, A. M. (2026). Impact of Municipal Solid Waste Compost on Soil Quality in Peri-Urban Farmlands of Katsina State, Nigeria. *UMYU Scientifica*, 5(2), 256 – 264. <https://doi.org/10.56919/usci.2652.024>

in agricultural systems (Adebayo, 2024). Similarly, Grema et al. (2022) demonstrated that biofertilizer and organic fertilizer applications significantly increased chlorophyll and moisture content in *Pennisetum typhoides* compared with untreated soils, further emphasizing the agronomic importance of organic soil amendments. Similarly, Adamu et al. (2023) reported heavy metal accumulation in agricultural soils in Northwestern Nigeria, emphasizing the importance of evaluating soil quality and environmental safety in amended soils. These findings underscore the need for an integrated assessment of soil fertility and contamination risks associated with the utilization of organic waste.

In modern agricultural systems characterized by the intensive use of synthetic inputs and increasing environmental pressures, soil quality assessment has become essential for monitoring soil condition and sustainability under different management practices. Soil quality is broadly defined as the capacity of soil to function within natural or managed ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health (Topa et al., 2025; Nunes, 2025). Unlike single-parameter evaluations, the Soil Quality Index (SQI) integrates physical, chemical, and biological properties into a unified framework for assessing soil performance under varying land-use systems and management conditions. This integrated approach provides a more holistic understanding of soil health because soil quality is influenced by both inherent properties, such as parent material, texture, and mineralogy, and dynamic properties affected by cultivation, fertilization, and organic amendments, including MSWC (Hamza et al., 2025; Nazrin & Arifin, 2025).

The physical component of soil quality governs soil structure, aeration, porosity, root penetration, water infiltration, and aggregate stability (Pandey, 2025). Important physical indicators include soil texture, bulk density, permeability, and water-holding capacity. Improved aggregate stability minimizes erosion and compaction while enhancing root growth and moisture retention. Compost amendments have been reported to significantly improve these physical characteristics by increasing soil organic matter and reducing soil bulk density (Khadim et al., 2024; Saikia et al., 2025). In addition, the chemical component of soil quality determines nutrient availability, buffering capacity, and potential soil toxicity. Soil pH strongly influences nutrient solubility and microbial activities, while nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) play critical roles in plant growth and productivity (Maryo et al., 2025). Soil organic matter also enhances cation exchange capacity, nutrient retention, and immobilization of potentially toxic elements such as cadmium, chromium, and lead (Ghosh & Ghoshal, 2026).

The biological component of soil quality comprises microorganisms, soil fauna, fungi, bacteria, and plant roots, which drive nutrient mineralization, organic matter decomposition, and pollutant detoxification (Prabhu et al.,

2025). Application of organic amendments, such as MSWC, generally stimulates microbial biomass and enzymatic activity due to increased organic substrate availability. Nevertheless, poorly managed composts may alter microbial community structure or introduce contaminants into the soil ecosystem (Munyaneza et al., 2026; Salma Santhosh et al., 2026). Studies related to waste-impacted environments and remediation processes have further highlighted the importance of biological interactions in maintaining ecological balance and soil functionality (Afegbua et al., 2023).

In Katsina State, Ibrahim et al. (2014) and Hassan and Ibrahim (2021) evaluated soil quality conditions in Kaita and Funtua Local Government Areas using individual soil fertility parameters. However, integrated evaluation of soil quality using physical, chemical, and biological indicators in municipal solid waste compost-amended peri-urban farmlands remains limited. Therefore, this study evaluates the impact of MSWC application on soil quality in peri-urban farmlands of Katsina State using the Soil Quality Index approach. Specifically, the study assesses selected soil fertility parameters and determines the influence of MSWC on overall soil quality status. The findings will contribute to the growing body of knowledge on sustainable waste utilization, soil fertility management, and environmentally sound agricultural practices in peri-urban agroecosystems.

MATERIALS AND METHODS

Description of Study Area

Katsina town is the capital city of Katsina State. It is located between Latitude 12° 45' and Latitude 13° 15' N, and Longitude 7° 30' and 8° 00' E. The location is in the extreme north of Nigeria (Figure 1), and it is the administrative headquarters of the Katsina Emirate.

The plain stands at an elevation of about 505m above sea level. The landforms reflect the sedimentary rock formations of the area, and the city is drained by the Rivers Ginzo and Tille. (MLSK, 2008). The Climate of Katsina is humid tropical, with two distinct wet and dry seasons. The rainfall is from April to October, ranging from 700 to 800mm annually, with 30 °C as the mean monthly dry season temperature (Asanarimam et al., 2015). Soil is typically alfisol, generally loose and sandy (Abdullahi, 2024). The vegetation is dominated by grass families and xerophytes species, such as fine-leaved *Acacia* spp. and their associates. Other vegetation types include Baobab (*Adansonia digitata*), Guiera (*Guiera senegalensis*), and Tamarind (*Tamarindus indica*).

Soil sampling

Farmlands under municipal solid waste compost amendment and its control were purposively selected. 1 km² was demarcated at each location, with 100 grids (small squares) of 100 m² established. Twenty samples, 20 each from the MSWC-amended and control locations, were collected at 0- 15 cm using composite sampling

procedures. The samples collected were kept in a clean polyethylene bag, labelled appropriately, and then taken to

the laboratory, where further treatment and analysis were performed.

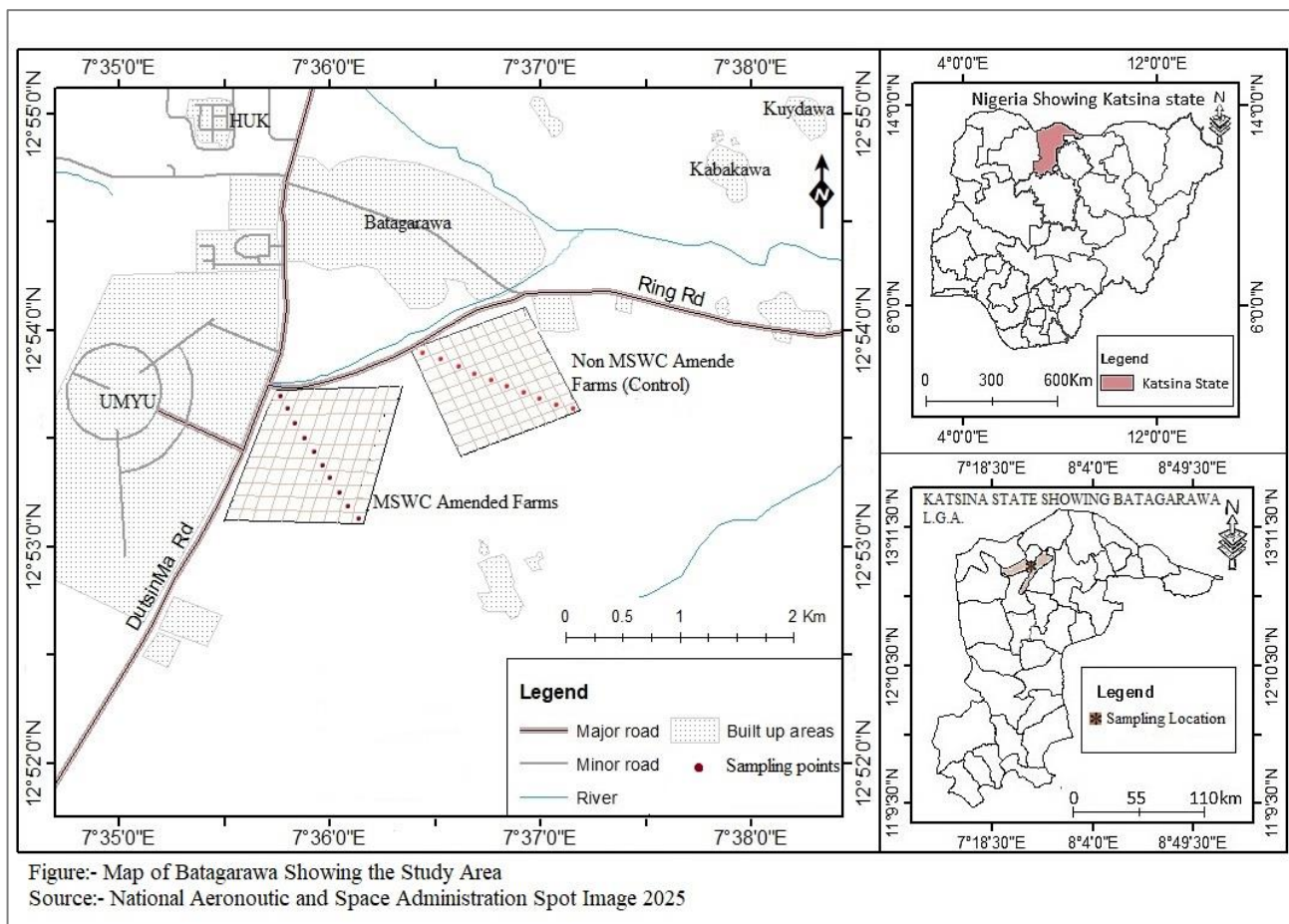


Figure: 1 Study area showing Peri-urban farmlands

Table 1: Methods of Laboratory Analysis

S/N	QUALITY PARAMETERS	METHOD USED
1	Particle Size Distribution	Bouyoucos hydrometer method (Buoyoucos, 1951)
2	Organic Carbon	Walkley-Black wet oxidation method (Mustapha, 2020).
3	Soil pH	electrode pH meter method (Galster, 1991).
4	Cd, Pb & Cr	Perkin Elmer 400 Atomic Absorption Spectrophotometer Method.
5	Total Nitrogen	Macro Kjeldahl method (Mustapha, 2020).
6	Available Phosphorous	Bray Ascorbic acid Molybdate (Olsen et al, 1954)
7	Soil Microbial Biomass	Fumigation Incubation Method (Jenkinson and Pawlson, 1976)
8	Soil Respiration	Incubation method (Alef and Nannipieri 1995).
9	Exchangeable Bases	Ammonium Acetate extraction method (Schollenberger and Simon, 1954).

Table 2: Soil Quality Index Value and Description

SQI Value	SQI Value Description	Level
0.49-0.56	Very High	1
0.45-0.49	High	2
0.41-0.45	Moderate	3
0.36-0.41	Low	4
0.29-0.36	Very LOW	5

Adapted from Karaca et al., (2021).

Laboratory Analysis

Different laboratory procedures and methods were used for different soil quality parameters, the summary of which is presented in Table 1.

Statistical Analysis

The data generated from laboratory analysis were analyzed using descriptive statistics, including mean, standard deviation, and coefficient of variability. However, t-tests

of means were used to determine significant differences in soil parameters between MSW compost-amended soil and its control locations.

Soil Quality Evaluation Model

The model uses soil physical, chemical and biological quality parameters to produce an SQI value.

Scoring Function for Soil Quality Evaluation

In agricultural soil, some soil quality parameters are needed in large quantities, such as nitrogen, phosphorus, organic carbon, and potassium, which are scored as more is better, while those needed in small quantities, such as bulk density and micronutrients, are scored as less is better, as shown in equations 2 and 3.

$$\text{More is better} = \frac{\text{Observed} - \text{Minimum}}{\text{Maximum} - \text{minimum}} \quad (\text{N, P, K, O.C., CEC,}) \quad 2$$

$$\text{Less is better} = \frac{\text{Maximum} - \text{Observed}}{\text{Maximum} - \text{minimum}} \quad (\text{Db, Cd, Pb, Cr}) \quad 3$$

Subjective expert opinion was used to weight soil parameters, giving greater weight to macronutrients (N, P,

K, O, C) that are essential to agricultural operations. At the same time, those required in small quantities by plants, such as micronutrients and bulk density, were given lower weights.

Soil Quality Index model

$$\text{SQI} = \sum_i^n W_i * S_i \quad 4$$

Where SQI = Soil Quality Index, W_i is the weighted value, and S_i is the transformed score for each soil quality indicator, and n is the number of MDS indicators (Martin-Sanz *et al*, 2022). The SQI value grading system is presented in Table 2.

RESULT AND DISCUSSION

The distribution of some selected soil fertility parameters was evaluated and presented in Table 3. The mean soil pH value is 7.6 (Table 3), which is alkaline, and this might be attributed to the presence of alkaline waste materials in the compost, such as eggshells, cement, ash, and other lime-based materials. The obtained value falls within the suitable range of 5-8 (Abdullahi, 2024) for millet and sorghum, which are among the most cultivated crops in the study area.

Table 3: Soil fertility parameters

Parameters	Mean	±SD	Cv	Mean	±SD	CV
		Contaminated			Control	
pH (HCl)	7.61	0.62	8.18	5.89	0.27	4.64
AVP (mg/Kg)	11.03	2.65	23.99	11.4	5.52	48.41
% N	0.17	0.05	28.22	0.12	0.04	34.1
K(Cmol/Kg)	0.65	0.32	49.23	0.23	0.21	90.91
Ca (Cmol/Kg)	1.98	1.03	52.07	0.52	0.07	13.85
Na (Cmol/Kg)	0.81	0.38	46.17	0.45	0.16	36.49
Mg (Cmol/Kg)	0.01	0.01	48.43	0.01	0	43.7
CEC (Cmol/Kg)	3.46	1.62	46.81	1.21	0.23	19.2
O.C (%)	0.734	0.27	36.78	0.534	0.11	20.59
MBC (%)	0.001	0.0004	40	0.0008	0.0002	25
Soil Resp. (mg/g of CO ₂)	0.122	0.06	49.18	0.174	0.13	74.71

Source: Field and Laboratory Data, 2025.

Table 4: Variability of soil quality parameters among the study locations

Soil Quality Parameter	std err	t-stat	p-value	t-crit	Lower	Upper	Sig	effect r
pH (HCl)	0.22	8.061	0	2.201	1.287	2.253	Yes	0.924
Organic matter (%)	0.218	1.541	0.143	2.12	-0.126	0.799	No	0.36
AVP (mg/Kg)	1.887	0.857	0.409	2.179	-5.729	2.495	No	0.244
N (%)	0.022	2.161	0.046	2.12	0.001	0.096	Yes	0.477
K(Cmol/Kg)	0.133	3.218	0.006	2.145	0.143	0.714	Yes	0.653
Ca (Cmol/Kg)	0.365	3.941	0.004	2.306	0.596	2.278	Yes	0.811
Na (Cmol/Kg)	0.142	2.525	0.029	2.201	0.046	0.673	Yes	0.614
Mg (Cmol/Kg)	0.003	0.295	0.772	2.12	-0.005	0.006	No	0.075
CEC (Cmol/Kg)	0.576	3.867	0.005	2.306	0.898	3.553	Yes	0.803

Source: Field and Laboratory Data, 2025.

Table 5: Soil Quality Index value

	MSWC	Control
SQI value	0.47±0.15	0.42± 25
Quality level	High	Moderate

Source: Field and Laboratory Data, 2025.

This result may be attributed to the high organic matter content of MSWC, which improves soil physical

properties, nutrient solubility and availability, soil texture, porosity, permeability, aeration, microbial activity, root

penetration, and development. The finding is in agreement with that of Saikia *et al.* (2025), and Khadim *et*

al. (2024), who reported a decrease in soil bulk density with MSWC application.

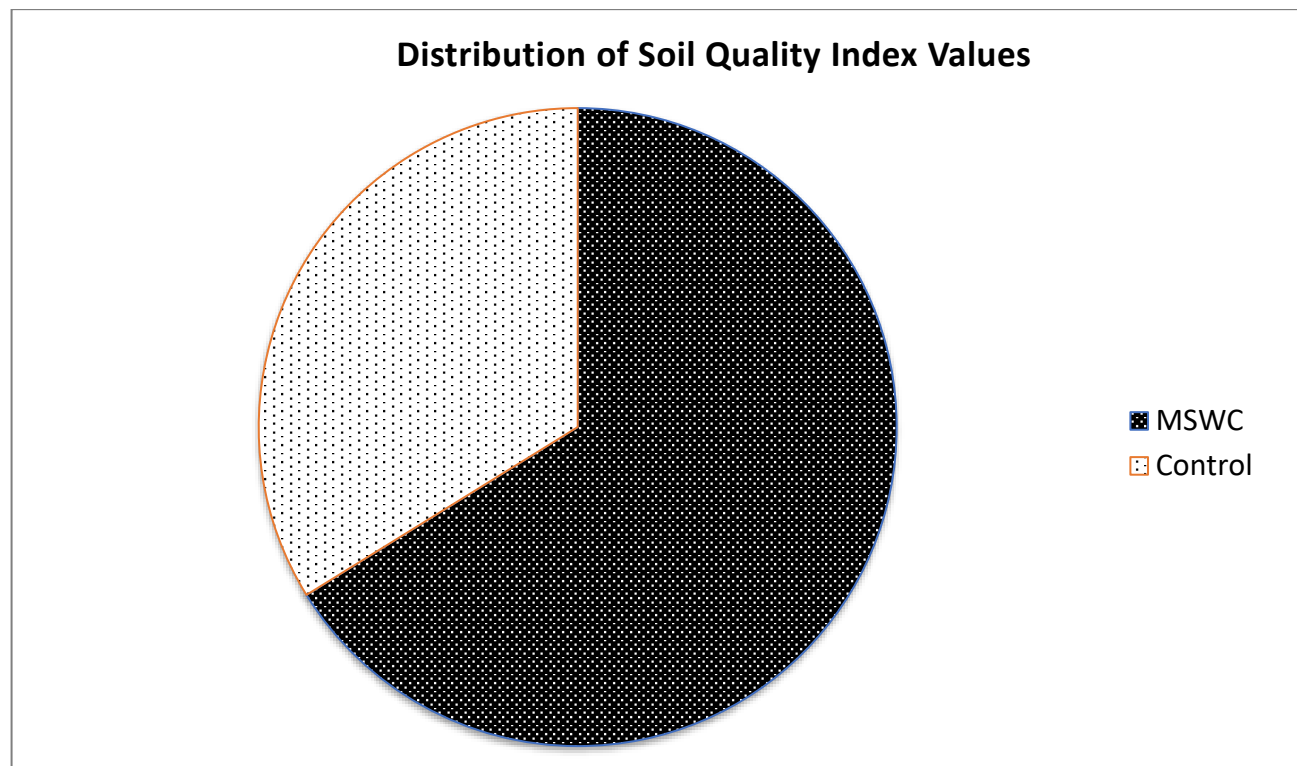


Figure 2: Distribution of Soil Quality Index Value Across Study Locations

Source: Field and Laboratory, 2025.

Table 6: Soil Quality Evaluation of MSWC-amended

Quality Indicator	Scoring Function	Normalize Score (S)	Weighted Value (W)	S*W
PH	Optimum is better	0.65	0.08	0.052
Total nitrogen	More is better	0.37	0.12	0.0444
Available Phosphorous	More is better	0.48	0.08	0.0384
Potassium (K)	More is better	0.55	0.08	0.044
Organic carbon (O.C)	More is better	0.47	0.12	0.0564
Calcium (Ca)	More is better	0.57	0.05	0.0285
Magnesium (Mg)	More is better	0.35	0.05	0.0175
Sodium (Na)	More is better	0.51	0.03	0.0153
CEC	More is better	0.56	0.08	0.0448
Lead (Pb)	Less is better	0.5	0.01	0.005
Cadmium (Cd)	Less is better	0.45	0.01	0.0045
Chromium (Cr)	Less is better	0.3	0.02	0.006
Soil Respirations	More is better	0.64	0.07	0.0448
MBC	More is better	0.17	0.08	0.0136
Soil Quality Index (SQI) Value				0.4756

Source: Field & Laboratory, 2025.

The mean value of soil available phosphorus is 11.03 mg/kg (Table 3), which is below the Olsen soil available phosphorus minimum threshold of 12mg/kg (Jalali *et al.*, 2025). Therefore, supplementary phosphate is required for optimum plant growth. The lower available phosphorus at the MSWC-Amended may be attributed to the low phosphorus source material. The finding has contended that of Sun *et al.* (2025), Manea *et al.* (2024), and Sifola *et al.* (2024), who reported higher values *in* the MSWC-Amended soil. The mean soil nitrogen (%) is 0.17% (Table 3), which may be linked to MSW compost's ability to supply organic nitrogen, thereby improving microbial activity, nitrogen fixation, the nitrogen cycle,

and retention via adsorption. Optimum soil nitrogen is essential for microbial activities, plant growth and development. Ahmed (2025) reports a nitrogen mean value of 0.20 % from millet cultivation field in southern Katsina State. The result corroborated the findings of Sun *et al.* (2025), Sifola *et al.* (2024), and Manea *et al.* (2024), who reported improved nitrogen concentration with increasing MSWC application. The mean exchangeable potassium (K) value is 0.65 mg/kg, which might be due to the fact that MSWC typically contains an appreciable amount of K+, which is released immediately after application, and continuous applications produce residual potassium.

Table 7: Soil quality index

Quality Indicator	Scoring Function	Normalize Score (S)	Weighted Value (W)	S*W
pH	Optimum is better	0.39	0.08	0.0312
Total nitrogen	More is better	0.61	0.12	0.0732
Phosphorous	More is better	0.47	0.08	0.0376
Potassium (K)	More is better	0.22	0.08	0.0176
Organic carbon	More is better	0.35	0.12	0.042
Calcium (Ca)	More is better	0.39	0.05	0.0195
Magnesium (Mg)	More is better	0.3	0.05	0.015
Sodium (Na)	More is better	0.42	0.03	0.0126
CEC	More is better	0.48	0.08	0.0384
Lead (Pb)	Less is better	0.4	0.01	0.004
Cadmium (Cd)	Less is better	0.3	0.01	0.003
Chromium (Cr)	Less is better	0.3	0.02	0.006
Soil Respirations	More is better	0.46	0.07	0.0322
MBC	More is better	0.33	0.08	0.0264
SQI Value				0.4243

Source: Field & Laboratory, 2025.

Potassium is essential for plant growth and metabolism; this value may help adequately regulate and support plant water use, drought and stress tolerance, disease and pest resistance, and increase yield and crop quality (Pandey & Saharan, 2025). Ahmed (2025) reports a potassium mean value of 0.030 Cmol/kg from a millet cultivation field in southern Katsina State; the result is in agreement with that of Seilsepour *et al.* (2025) and Manea *et al.* (2024), who reported increasing soil potassium concentration with MSWC application.

Variability of Soil Quality Parameters Among Study Locations

The results from the paired t-test analysis showed that a significant statistical difference exists between MSWC-amended and control soil for soil pH, nitrogen, potassium, calcium, sodium, and cation exchange capacity (CEC), while organic matter, available phosphorus, and magnesium (Table 4) showed no significant statistical difference between the two treatments. This significant statistical difference may be attributed to the beneficial components of MSWC. The implication is improvement of soil physical, chemical and biological properties. Higher potassium, calcium, and magnesium levels in MSWC replace hydrogen ions on exchangeable sites, thereby increasing soil pH (Mourya *et al.*, 2024). High soil pH decreases heavy metal mobility and toxicity and improves microbial activity, nutrient availability, and aggregate stability (Zhao *et al.*, 2025). Low density of organic matter (0.3-0.6 cm³) when mixed with mineral soil (2.6 cm³) dilutes the mineral particles per unit volume, thereby decreasing the overall soil bulk density, which eventually improves soil aggregate, porosity, microbial activities, root penetration and water infiltration and reduces compaction (Khadim *et al.*, 2024).

Soil Quality Status in the Study Locations

Soil quality is the overall ability of soil to perform its functions sustainably and support productivity, environmental quality, and biological health (Delgado & Gómez, 2024). It can be achieved through supporting plant growth, regulating water, filtering and buffering

pollutants, recycling nutrients and organic matter, and providing habitat for soil organisms, and depends largely on soil physical, chemical, and biological properties (Panda, 2025; Delgado & Gómez, 2024).

The soil quality index values were determined using the soil quality index (SQI) model. The highest and lowest mean soil quality index (SQI) values were recorded at MSWC-Amended (0.47) and control (0.42), respectively (Table 5). MSWC-Amended demonstrated a higher mean soil quality index value than the control, as described by Karaca *et al.* (2021). This result might be attributed to the presence of beneficial components of MSWC. The implication of a high SQI value in MSWC-amended soil is that it improves the physical, chemical, and biological aspects of the soil matrix, which in turn enhances soil functional potential. Tadesse (2021) reports an average soil quality of 0.7015 from Ethiopian agricultural lands. The finding corroborates Mamehpour *et al.*, (2021), who reported increased soil quality with increasing urbanization.

The pie chart in Figure 2 depicts the potential impact of municipal solid waste compost to enhance soil condition by enhancing a wide range of soil quality parameters and processes happening within the soil ecosystem, which suggest for increased investment in MSWC through increased research, awareness among farmers, generation, application and development of regulatory guidelines to guide the process.

Table 6 shows the quality index value of the municipal solid waste compost (MSWC) 0.4756, while Table 7 reported soil quality index value from the non-MSWC-amended soil 0.4243, indicating higher quality index value at MSWC-amended soil, which might be attributed to the higher organic matter content of the MSWC capable of improving the physical, chemical and biological properties of the soil.

Implications of Increased Soil Quality Due to MSWC Application

The MSWC application improved soil physical properties, including enhanced soil aggregate stability, porosity, and

water-holding capacity. Reduced bulk density and compaction translate into better root penetration, reduced erosion and runoff and improved drought resistance (Greeshma *et al.*, 2025). Soil chemical properties are enhanced through increased availability of nitrogen, phosphorus and potassium. Increased cation exchange capacity, which increases fertilizer-use efficiency and reduces nutrient loss to groundwater (Iqbal *et al.*, 2025). Increased soil quality index value may improve microbial biomass and diversity and stimulation of beneficial bacteria species such as *Bacillus spp.*, *Pseudomonas spp.* and *Actinomyces* and enzyme activities (*dehydrogenase*, *urease* and *phosphatase*), which in turn improve nutrient cycling and soil resilience (Das *et al.*, 2025; Bhat *et al.*, 2025). This finding may immobilize potential toxic elements (PTE) through the formation of organic matter complexes, thereby reducing metal uptake by plants and lowering ecological and human health risks (Aslam *et al.*, 2025). It may increase plant growth and productivity through improved seed germination and root growth, increased biomass, and enhanced crop and nutrient uptake efficiency, thereby ensuring sustainable crop production and reduced dependency on synthetic fertilisers (Somaly & Sokra, 2026). Environmental and ecological benefits may be achieved by enhancing soil carbon sequestration, reducing greenhouse gas emissions compared to chemical fertilisers, and improving soil ecosystem stability, all of which are integral to climate-smart soil management and improved ecosystem services (Wang *et al.*, 2025). Improving soil quality through MSWC application may contribute to socioeconomic and waste management benefits, as it converts municipal waste into productive inputs, reduces landfill burden and costs, and serves as a cost-effective soil amendment. These benefits will promote the circular economy and Sustainable waste management (Madhavaraj *et al.*, 2025; Kumar *et al.*, 2025).

CONCLUSION

It can be concluded that the application of municipal solid waste compost (MSWC) to agricultural fields improved overall soil quality for agricultural production and the soil ecosystem as a whole.

RECOMMENDATION

Soil testing should be carried out before amendment to match amendment with plant nutrients demand.

Source separation should be considered before composting to remove potentially toxic elements (PTEs) from waste materials.

LIMITATION OF THE STUDY

Subjectively, some crops need more of certain soil nutrients than others.

Limited previous studies on MSWC amendment in the area for result validation

REFERENCES

Abdullahi, S. (2024). Physiochemical soil properties assessment for sustainable agriculture in Katsina

North Senatorial Zone, Katsina State, Nigeria. *International Journal of Agriculture and Biology Research*, 12(3), 41-56.

- Adamu, S. B., Aliyu, I. F., Musa, L. Y., Kamil, K. K., Afeez, A. O., Muhammad, I. C., Mikailu, A., Rabi, T. A., Garba, I. S., Garba, S. D. I., Thomas, D. O., & Yakubu, Y. Y. (2023). Quantification of pollution index of selected heavy metals in agricultural soils in Kafin Hausa Area, Northwest Nigeria. *UMYU Scientifica*, 2(4), 150-160. [Crossref]
- Adebayo, K. R. (2024). Impact of magnetized irrigation water treatment on nutrients uptake and water use efficiency of cowpea cultivar (*Vigna unguiculata* L.). *UMYU Scientifica*, 3(2), 164-172. [Crossref]
- Afegbua, S. L., Batty, L. C., & Renshaw, J. C. (2023). Effect of different diesel treatments on growth of single and mixed plant communities and petroleum hydrocarbon dissipation during rhizoremediation. *UMYU Scientifica*, 2(3), 1-8. [Crossref]
- Ahmed, M. M. (2025). Impact of physicochemical properties of soil on crop cultivation in Southern Katsina State, Nigeria. *African Journal of Earth and Environmental Science*, 7(1), 45-54.
- Alef, K., & Nannipieri, P. (Eds.). (1995). *Methods in applied soil microbiology and biochemistry*. 2(8), 57-76.
- Asanarimam, S. A., Yakubu, A. A., Mashi, A. S., Daniel, S. G., & Kwesaba, D. A. (2015). An assessment of flood hazard responses among the residents of Katsina Metropolis, Katsina State, Nigeria. *Asian Journal of Basic and Applied Sciences*, 3(1), 31-47. [Link]
- Aslam, A., Kanwal, F., Javed, S., Nisar, N., & Torriero, A. A. J. (2025). Microbial biosorption: A sustainable approach for metal removal and environmental remediation. *International Journal of Environmental Science and Technology*, 22(13), 13245-13276. [Crossref]
- Basurto-Lozada, D., Hillier, A., Medina, D., Pulido, D., Karaman, S., & Salas, J. (2020). Dynamics of soil surface temperature with unmanned aerial systems. *Pattern Recognition Letters*, 138, 68-74. [Crossref]
- Bhat, M. M., Bashir, Z., Hamid, B., & Nisa, M. (2025). Impact of the synthetic fertilizer pesticides on soil health and soil microbiology. In *Organic farming* (pp. 282-302). CRC Press. [Crossref]
- Bouyoucos, G. H. (1951). A recalibration of hydrometer for making mechanical analysis of soil. *Journal of Agronomy*, 43, 434-438. [Crossref]
- Das, D., Riamei, M., Paul, P., Singh, N., Ingti, B., Sarkar, R. D., ... & Paul, S. (2025). Understanding the role of soil microorganisms in alleviating hydric and edaphic stress towards sustainable agriculture. *Discover Soil*, 2(1), 47-59. [Crossref]
- Delgado, A., & Gómez, J. A. (2024). The soil: Physical, chemical, and biological properties. In *Principles of agronomy for sustainable agriculture* (pp. 15-30). Springer International Publishing. [Crossref]

- Devi, S., & Singh, S. (2023). Soil organic carbon sequestration in dryland soils to alleviate impacts of climate change. In *Enhancing resilience of dryland agriculture under changing climate: Interdisciplinary and convergence approaches* (pp. 221-245). Springer Nature Singapore. [\[Crossref\]](#)
- Ferro, G. (2021). Understanding the circular economy: Overview of the issues. *Serie Documentos de Trabajo-Nro*, 809. [\[Crossref\]](#)
- Galster, H. (1991). *pH measurement*. VCH.
- Ghosh, P., & Ghoshal, A. (2026). Potentially toxic elements (PTEs) in plants and animals: Environmental pathways, toxicity mechanisms, and biomonitoring insights. *Environmental Quality Management*, 35(3), 70-99. [\[Crossref\]](#)
- Greeshma, P. R., Leno, N., & Rani, B. (2025). Organic waste recycling through composting: An environmental perspective. *International Journal of Environment and Climate Change*, 15(5), 259-275. [\[Crossref\]](#)
- Grema, M. N., Ismail, H. Y., & Muhammad, S. (2022). Comparative study on the effect of biofertilizer, organic and inorganic fertilizers on chlorophyll and moisture contents of *Pennisetum typhoides*. *UMYU Scientifica*, 1(2), 1-7. [\[Crossref\]](#)
- Hamza, A., Karčauskienė, D., Mockevičienė, I., Repšienė, R., Tahir, M. A., Manzoor, M. Z., & Ullah, I. (2025). Soil aggregate dynamics and stability: Natural and anthropogenic drivers. *Agriculture*, 15(23), 25-42. [\[Crossref\]](#)
- Hassan, M., & Ibrahim, S. (2021). Soil quality evaluation in agricultural soils of Funtua Area, Katsina State, Northwestern, Nigeria. *International Journal of Science for Global Sustainability*, 7(2), 50-59.
- Hauser, S., Saito, K., & Pulleman, M. (2023). Soil sampling (disturbed and undisturbed), handling and storage for soil chemical, biological and physical properties. *Journal of Soil Science*, 2(6), 171-189.
- Hong, Y. K., Yoon, D. H., Kim, J. W., Chae, M. J., Ko, B. K., & Kim, S. C. (2021). Ecological risk assessment of heavy metal-contaminated soil using the triad approach. *Journal of Soils and Sediments*, 2(1), 2732-2743. [\[Crossref\]](#)
- Ibrahim, U. B., Fardami, A. Y., Sabitu, M., Aliyu, A., Jodi, A. M., Hauwau, H., Lawal, I., Isah, M., & Dalhatu, A. I. (2024). The attributes of biofertilizer as an alternative to chemical fertilizer: A mini review. *UMYU Scientifica*, 3(1), 208-214. [\[Crossref\]](#)
- Ibrahim, Y., Nuraddeen, A. M., & Abubakar, A. R. (2014). Factors affecting soil quality maintenance in northern Katsina State, Nigeria. *Science World Journal*, 9(4), 87-102.
- Iqbal, B., Zhou, H., Raheem, A., Inamullah, Zheng, T., Khan, A. R., ... & Du, D. (2025). The impact of land use changes and agricultural practices on phosphorus cycling: A review. *Land Degradation & Development*, 4(3), 232-246.
- Isiya, S., & Salisu, B. (2024). Biofertilizer production using phosphate-solubilizing *Pseudomonas* spp. isolated from rhizosphere soil: Towards indigenous biofertilizer for enhanced crop productivity in Katsina, Nigeria. *UMYU Journal of Microbiology Research (UJMR)*, 9(1), 123-133. [\[Crossref\]](#)
- Jalali, M., Jalali, M., & Weaver, D. (2025). Critical soil phosphorus levels: A review. *Nutrient Cycling in Agroecosystems*, 5(2), 1-46. [\[Crossref\]](#)
- Jenkinson, D. S., & Powlson, D. S. (1976). The effects of biocidal treatments on metabolism in soil-V: A method for measuring soil biomass. *Soil Biology and Biochemistry*, 8(3), 209-213. [\[Crossref\]](#)
- Karaca, S., Dengiz, O., Turan, İ. D., Özkan, B., Dedeoğlu, M., Gülser, F., & Ay, A. (2021). An assessment of pasture soils quality based on multi-indicator weighting approaches in semi-arid ecosystem. *Ecological Indicators*, 12(1), 107-118. [\[Crossref\]](#)
- Khadim, M. D., Wesal, A. B., & Peezhand, A. W. (2024). Overview of the impact of compost on bulk density, aggregate consistency and cation exchange capacity of soils and its consequential effect on crop productivity. *Cognizance Journal of Multidisciplinary Studies*, 4(6), 344-359. [\[Crossref\]](#)
- Kumar, R., Gupta, G., Hussain, A., Rani, A., Thapliyal, A., Gunsola, D., ... & Mitra, D. (2025). Pioneering zero-waste technologies utilization and its framework on sustainable management: International, national and state level. *Discover Applied Sciences*, 7(3), 224-241. [\[Crossref\]](#)
- Madhavaraj, M., & Karthikeyan, K. (2025). A review of municipal solid waste management and landfills in India: Environmental impacts, sustainable strategies and policy insights. *Journal of Material Cycles and Waste Management*, 8(2), 1-24. [\[Crossref\]](#)
- Mamehpour, N., Rezapour, S., & Ghaemian, N. (2021). Quantitative assessment of soil quality indices for urban croplands in a calcareous semi-arid ecosystem. *Geoderma*, 382, 114-131. [\[Crossref\]](#)
- Manea, E. E., Bumbac, C., Dinu, L. R., Bumbac, M., & Nicolescu, C. M. (2024). Composting as a sustainable solution for organic solid waste management: Current practices and potential improvements. *Sustainability*, 16(15), 63-75. [\[Crossref\]](#)
- Martin-Sanz, J. P., de Santiago-Martin, A., Valverde-Asenjo, I., Quintana-Nieto, J. R., Gonzalez-Huecas, C., & Lopez-Lafuente, A. L. (2022). Comparison of soil quality indexes calculated by network and principal component analysis for carbonated soils under different uses. *Ecological Indicators*, 143, 109-124. [\[Crossref\]](#)
- Maryo, M., Fitamo, D., & Kebede, F. (2025). Soil fertility status and nutrient management implications for Arabica coffee (*Coffea arabica* L.) in the Gedeo Zone's agroforestry systems, Southern Ethiopia. *Agroforestry Systems*, 99(8), 1-20. [\[Crossref\]](#)
- Ministry of Lands and Survey. (2008). *History and masterplan of Katsina*. Survey Department, Government Printing Press, Katsina State. p. 187.
- Mourya, K. K., Barman, A., Hota, S., Tiwari, G., Verma, S., Kumar, A., ... & Saikia, U. S. (2024). Land degradation neutrality: Concept and approaches.

- In *Regenerative agriculture* (pp. 71-93). CRC Press. [\[Crossref\]](#)
- Munyaneza, V., Zhang, W., Haider, S., Ren, L., Song, H., Yi, B., ... & Ding, G. (2026). Soil microorganisms as drivers of pollutant degradation, metal detoxification, and sustainable agriculture. *Journal of Agricultural and Food Chemistry*, 2(4), 89-105. [\[Crossref\]](#)
- Mustapha, A. A. (2020). Comparison of different methods for the assessment of soil organic carbon in Northern Guinea Savanna Zone of Nigeria. *Journal of Sustainable Agriculture and the Environment (JSAE)*, 18(1), 36-41.
- Nabi, F., Sarfaraz, A., Kama, R., Kanwal, R., & Li, H. (2025). Structure-based function of humic acid in abiotic stress alleviation in plants: A review. *Plants*, 14(13), 19-37. [\[Crossref\]](#)
- Nazrin, M., & Arifin, A. (2025). Soil quality dynamics under tropical land-use change: Implications for sustainable management. *Environmental Monitoring and Assessment*, 197(12), 137-148. [\[Crossref\]](#)
- Nunes, M. R. (2025). A 30-year overview of soil fertility, soil quality, and soil health research in Florida. *Ecological Indicators*, 1(6), 113-132.
- Olsen, S. R. (1954). *Estimation of available phosphorus in soils by extraction with sodium bicarbonate* (No. 939). U.S. Department of Agriculture.
- Panda, S. (2025). Soil and water conservation for sustainable resources and ecosystem resilience. In *The Palgrave encyclopedia of sustainable resources and ecosystem resilience* (pp. 1-81). Springer Nature Switzerland. [\[Crossref\]](#)
- Pandey, K., & Saharan, B. S. (2025). Potassium-solubilizing endophytes: Mechanisms and applications in enhancing sustainable agriculture and plant resilience. *Symbiosis*, 3(4), 1-15. [\[Crossref\]](#)
- Pandey, T. (2025). *Introduction to soil mechanics*. Educohack Press.
- Prabhu, S., Poorniammal, R., & Dufossé, L. (2025). Microbial metabolites: A sustainable approach to combat plant pests. *Metabolites*, 15(6), 41-58. [\[Crossref\]](#)
- Saikia, S., Prit, H., Maturi, K. C., & Kalamdhad, A. S. (2025). Amendment of nutrient-deficient alluvial soil by municipal solid waste char and compost for the remediation of contaminants and enhancement of plant growth. *Water, Air, & Soil Pollution*, 236(4), 1-20. [\[Crossref\]](#)
- Salma Santhosh, S., Meena, S., Baskar, M., Karthikeyan, S., Vanniarajan, C., & Ramesh, T. (2025). Transformative strategies for saline soil restoration: Harnessing halotolerant microorganisms and advanced technologies. *World Journal of Microbiology and Biotechnology*, 41(5), 140. [\[Crossref\]](#)
- Schollenberger, C. J., & Simon, R. H. (1945). Determination of exchange capacity and exchangeable bases in soil-ammonium acetate method. *Soil Science*, 59(1), 13-24. [\[Crossref\]](#)
- Seilsepour, M., & Moharami, S. (2025). Effect of nitrogen and municipal solid waste compost on the physicochemical properties of a calcareous soil under wheat cultivation. *Communications in Soil Science and Plant Analysis*, 56(5), 701-712. [\[Crossref\]](#)
- Sharma, P. K., & Kumar, S. (2023). Soil structure and plant growth. In *Soil physical environment and plant growth: Evaluation and management* (pp. 125-154). Springer International Publishing. [\[Crossref\]](#)
- Sifola, M. I., Cozzolino, E., Todisco, D., Palladino, M., Sicignano, M., & del Piano, L. (2024). Organic fraction municipal solid waste compost and horse bean green manure improve sustainability of a top-quality tobacco cropping system: The beneficial effects on soil and plants. *Sustainability*, 16(15), 64-76. [\[Crossref\]](#)
- Somaly, S., & Sokra, I. (2026). Factors affecting plant growth: A comprehensive review. *Journal of Agriculture and Technology*, 2(1), 91-96.
- Sun, L., Guan, W., Tai, X., Qi, W., Zhang, Y., Ma, Y., ... & Lin, D. (2025). Research progress on microbial nitrogen conservation technology and mechanism of microorganisms in aerobic composting. *Microbial Ecology*, 88(1), 1-14. [\[Crossref\]](#)
- Tadesse, G. M. T. (2021). Assessment of soil quality index for agricultural purpose in Agamsa sub-watershed, Ethiopia. *Journal of Soil Science*, 2(6), 125-141.
- Țopa, D. C., Căpșună, S., Calistru, A. E., & Ailincăi, C. (2025). Sustainable practices for enhancing soil health and crop quality in modern agriculture: A review. *Agriculture*, 15(9), 99-108. [\[Crossref\]](#)
- USDA-NRCS. (1999). *Soil quality information sheet: Soil quality indicators - Bulk density*. Soil Quality Institute, Auburn, AL.
- Wang, P., Yu, A., Wang, F., Shang, Y., Wang, Y., Yin, B., ... & Zhang, D. (2025). Mechanistic insights into farmland soil carbon sequestration: A review of substituting green manure for nitrogen fertilizer. *Agronomy*, 15(5), 10-42. [\[Crossref\]](#)
- Zaman, A. U. (2016). A comprehensive study of the environmental and economic benefits of resource recovery from global waste management systems. *Journal of Cleaner Production*, 124, 41-50. [\[Crossref\]](#)
- Zhao, Q., Tang, W., Han, M., Cui, W., Zhu, L., Xie, H., ... & Wu, F. (2023). Estimation of reduced greenhouse gas emission from municipal solid waste incineration with electricity recovery in prefecture- and county-level cities of China. *Science of the Total Environment*, 875, 16-26. [\[Crossref\]](#)