IECAG 2025 Conference
The 5th International Electronic Conference on Agronomy
15–18 December 2025 | Online
MDPI

Influence of Municipal Refuse Waste used as Fertilizer on Soil Physical and Chemical Properties

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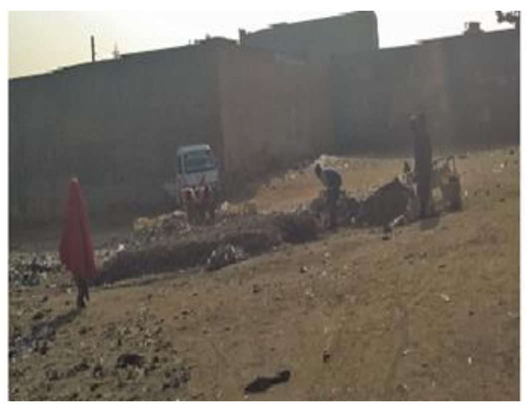
INTRODUCTION & AIM

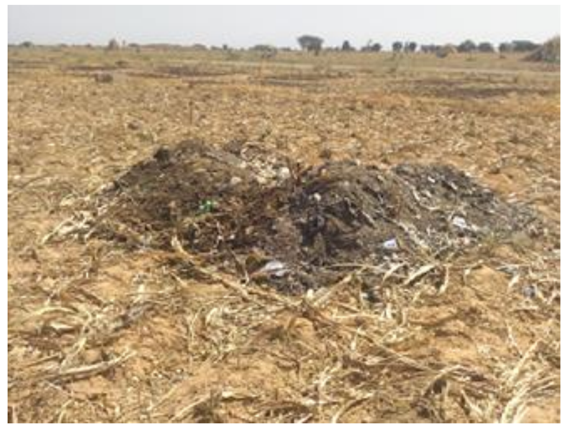
INTRODUCTION

- In Northern Nigeria, particularly in Kano State, soil degradation has become a pressing concern due to continuous cultivation, erosion, and limited organic matter input.
- The rising cost and inconsistent supply of inorganic fertilizers, smallholder farmers increasingly turn to alternative nutrient sources such as municipal refuse waste (MRW).
- Several studies have highlighted the benefits of organic waste in improving soil structure, increasing microbial activity, and enhancing the water-holding capacity of soils (Brady and Weil, 2016; García-Orenes et al., 2014).
- However, concerns have also been raised about the risks associated with the indiscriminate application of untreated MRW by urban and peri-urban farmers as a substitute for inorganic fertilizer, thereby resulting in contamination of soil with heavy metals.

OBJECTIVES OF THE STUDY

- To evaluate the effect of municipal refuse dump soil on soil texture.
- To determine the impact of municipal refuse dump soil on the chemical properties of the soil.
- To assess the concentration of heavy metals and other contaminants in soil treated with Municipal Refuse Waste as fertilizer.





METHODOLOGY

Description of the Study Area

Kano State, located in the Sudan Savanna ecological zone of Nigeria, lies approximately between latitudes 12°N and 13°N and longitudes 8°E and 9°E, with an annual rainfall range between 800 mm and 1000 mm. Average daily temperatures range from 20°C during the harmattan to over 39°C during the peak of the dry season. The region is dominated by sedimentary formations, primarily the Chad Formation and Sokoto Basin deposits, consisting of silt, clay, and sandstone. These parent materials contribute to the development of sandy and loamy sand soils prevalent in the area.

Site Selection and Soil Sampling

Three Local Government Areas (Fagge, Ungogo, and Dawakin Tofa) were selected based on their utilization of municipal refuse waste (MRW) as fertilizer. In each LGA, three farms utilizing MRW were selected, as well as one additional farm that did not apply MRW to served as the control, giving a total of 12 sampling sites.

Each farmland was divided into three section, five topsoil samples were randomly collected at 0–15 cm depth from each section using a sampling auger and then composite.

Sample Preparation

Air dried at Room Temperature → Crushes (mortar and pestle → Sieve (through a 2mm Siever)

Soil Analysis

- The particle size distribution was determined using the hydrometer method
- The soil pH was determined in both distilled water and 0.01M $CaCl_2$ using a calibrated glass-electrode pH meter at a ratio of 1:2.5 soil-to-solution (Thomas, 1996).
- Electrical conductivity (EC) was measured using a conductivity meter in a 1:5 soil-water suspension and expressed in deciSiemens per meter (dS/m).
- Percent organic carbon was determined using the Walkley-Black wet oxidation method
- Total nitrogen was analyzed using the Kjeldahl digestion technique.
- Available phosphorus was extracted using the Bray-1 method, suitable for acidic soils and measured in a spectrophotometer at 880 nm.
- Exchangeable bases (Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+}) were extracted with neutral 1N ammonium acetate (NH_4OAc) and measured using Atomic Absorption Spectrophotometry (AAS) for Ca and Mg, and Flame Emission Spectrophotometry for Na and K.
- Exchangeable acidity (extraction with 0.01N KCl and titration methods)
- Micro Nutrient/Heavy metals concentration (mild acid extraction 0.5 M HCl and 0.012 M H_2SO_4) and Atomic adsorption spectrophotometry.

Data analysis

data were subjected to one-way ANOVA using Genstat software and where significances differences were observed, means were separated using least significant difference (LSD), and the precision of these differences was assessed using the standard error of the difference (SED).

RESULTS & DISCUSSION

Results

Table 1. Particle Size Distribution of the soil across the study areas.

LOCATION	SAND (%)	SILT (%)	CLAY (%)	TEXTURAL CLASS
Fagge	77.22^{b}	15.00^{b}	7.778^{a}	Loamy Sand
Ungogo	77.44^{b}	17.67^{a}	4.889^{bc}	Loamy Sand
D/Tofa	78.55^{b}	15.23^{b}	6.222^{b}	Loamy Sand
Control	82.77^{a}	13.23^{b}	4.000^{c}	Loamy Sand
SE(±)	1.380	1.049	0.692	
LSD	2.847	2.165	0.692	
Significance	**	**	**	

Probability at 5% significant difference, Fagge, Ungogo, D/Tofa (farmlands location that utilize Municipal Refuse Waste Materials as Fertilizer), Control (Farmlands that does not utilize municipal refuse waste material as fertilizer)

Highly Significant difference (p<0.001) were observed between municipal refuse waste (MRW) amended soils and the control. These changes in texture shows that the addition of organic amendments can improve soil structure and microbial activities in the soil that speedup rate of mineral weathering

Table 2. Chemical Properties of the soil across the study areas.

Location	pH (H_2O)	pH ($CaCl_2$)	E.C dS/m	E.Acidity Cmol/Kg	O.C %	Ca	Mg	Na	K	Ex. Base	N %	Avail.P mg/kg
						←		Cmol/Kg		→		
Fagge	6.322^{ab}	5.710^{a}	0.10618^{a}	0.2407^{a}	0.7909^{a}	3.327^{a}	2.770^{a}	0.2804^{a}	0.2718^{a}	6.649^{a}	0.1618^{a}	30.81^{a}
Ungogo	6.180^{bc}	5.636^{a}	0.07872^{a}	0.2222^{a}	0.7643^{a}	2.317^{b}	2.033^{b}	0.2725^{a}	0.2005^{b}	4.823^{b}	0.1680^{a}	23.52^{a}
D/Tofa	6.054^{c}	5.647^{a}	0.07087^{a}	0.2778^{a}	0.5621^{b}	1.884^{b}	1.722^{bc}	0.1718^{b}	0.1838^{b}	3.961^{bc}	0.1027^{b}	27.65^{a}
CNT	6.403^{a}	5.553^{a}	0.05452^{a}	0.2778^{a}	0.2733^{c}	1.202^{c}	1.264^{c}	0.2154^{b}	0.1239^{c}	2.805^{c}	0.1587^{a}	18.15^{a}
SE(±)	0.0855	0.0778	0.01904	0.0424	0.0799	0.293	0.343	0.02331	0.02787	0.616	0.02430	7.09
LSD	0.1764	0.1606	0.03930	0.0876	0.1650	0.605	0.708	0.04811	0.05752	1.272	0.05015	14.64
Significance	**	NS	NS	NS	**	**	**	**	**	**	*	NS

Probability at 5% significant difference, Fagge, Ungogo, D/Tofa (farmlands location that utilize Municipal Refuse Waste Materials as Fertilizer), CNT (Farmlands that does not utilize municipal refuse waste material as fertilizer)

MRW addition shows a significant difference (p<0.001) in some chemical properties such as pH (water), percentage organic carbon, Exchangeable bases concentration. Slight significant difference in Percentage Nitrogen, while no significant difference in pH (Calcium Chloride), Electronic conductivity, Exchangeable acidity and Available phosphuros

Table 3. Micronutrient/Heavy Metals Contents of the soil across the study areas.

Location	Fe	Mn	Cu	Zn	Pb	Cd	Cr	Ni
		←			Mg/kg		→	
Fagge	11.97^{a}	23.55^{a}	2.714^{a}	38.94^{a}	0.0000^{a}	-	0.03874^{b}	0.005409^{a}
Ungogo	12.10^{a}	26.25^{a}	1.108^{a}	25.89^{ab}	1.9571^{a}	-	0.04197^{b}	0.002751^{a}
D/Tofa	11.29^{a}	18.77^{b}	0.826^{a}	10.05^{bc}	0.0000^{a}	-	0.05179^{a}	0.000000^{a}
Control	6.11^{b}	11.85^{c}	0.633^{a}	4.01^{c}	0.0000^{a}	-	0.03350^{c}	0.005400^{a}
SE(±)	1.848	2.252	0.831	10.18	0.949	-	0.002371	0.002461
LSD	3.814	4.648	1.715	21.00	1.958	-	0.004894	0.005080
Significance	*	**	NS	*	NS	-	**	NS
Critical Limit	2.5	5.0	1.5	2.0	5.0	0.8	0.05	1

Probability at 5% significant difference, Fagge, Ungogo, D/Tofa (farmlands location that utilize Municipal Refuse Waste Materials as Fertilizer), CNT (Farmlands that does not utilize municipal refuse waste material as fertilizer)

Result of heavy metal analysis shows significant difference (p<0.001) between MRW treated soil and control in terms of Mn, Cr, with slight difference in Fe, Zn and no significant difference in Cu, Pb and Ni.

Discussion

- MRW-treated soils shows slightly higher silt and clay, indicating improved aggregation and water-holding capacity (Brady & Weil, 2017).
- MRW application increased organic carbon and exchangeable bases (Ca, Mg, K, Na), showing nutrient enrichment through organic matter mineralization (Adekiya et al., 2019).
- Available phosphorus increased in MRW-treated soils due to decomposition of organic residues and mineral release (Olowoboko et al., 2020).
- Heavy metals (Fe, Mn, Zn, Cr) were higher in treated soils but remained below critical limits, implying low contamination risk (Kabata-Pendias & Pendias, 2011).
- Cd and Pb were negligible, indicating safe levels under current MRW application, though long-term monitoring is advised (Yusuf et al., 2018).

CONCLUSION

- Municipal refuse waste, when applied as a soil amendment, can significantly enhance soil fertility by increasing organic matter content and improving the availability of essential nutrients (such as N, P, Ca, Mg K, Na).
- These improvements in soil fertility can contribute to higher agricultural productivity and serve as a cost-effective alternative to chemical fertilizers.
- MRW slightly improved soil texture, making it more conducive to moisture retention and root development.
- the presence of elevated levels of potentially toxic elements especially lead raises important concerns. Without proper sorting, treatment, and regulation, the long-term use of untreated municipal waste could compromise soil health, crop safety, and public well-being.

FUTURE WORK / REFERENCES

Recommendations/Future work

- Further research should assess bioavailability of heavy metals in crops grown on MRW-amended soils to understand potential food chain risks, since current results cover only soil concentrations.
- There is need to explore safe composting and waste segregation methods before applying MRW to farmland to minimize contamination risks.
- Comparative studies involving different composting methods or waste treatment processes before field application should be conducted to identify safe and efficient MRW formulations.
- Establishing central composting facilities and continuous public awareness programs will enhance safe recycling of urban waste for soil fertility improvement in Kano State.
- Expanding the study to include different soil types and climatic zones within the Guinea Savannah could provide broader insight into MRW performance and environmental sustainability.

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