

ZIBELINE INTERNATIONAL™
PUBLISHING

ISSN: 2521-0858 (Print)

ISSN: 2521-0866 (Online)

CODEN: SHJCAS



RESEARCH ARTICLE

MULTI LOCATION FIELD EXPERIMENT ON IMPACTS OF COMMONLY USED HERBICIDES ON SOIL PHYSICOCHEMICAL PROPERTIES AND MICROBIAL LOAD IN MAKURDI LGA, BENUE STATE, NIGERIA

Idakwo Samuel, Onekutu Amana, Ebah Esther and Daniel Edinoh

*Environmental Science Unit, College of Biological Sciences, Joseph Sarwuan Tarka University Makurdi***Corresponding Author Email : danedinoh99@gmail.com*

This is an open access article distributed under the Creative Commons Attribution License CC BY 4.0, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

ARTICLE DETAILS

Article History:

Received 23 September 2025

Revised 28 October 2025

Accepted 26 November 2025

Available online 08 December 2025

ABSTRACT

The aim of this study was to determine the effects of commonly used herbicides on soil physicochemical properties and microbial load in three different communities (locations) in Makurdi LGA (Local Government Area) of Benue State, Nigeria. Three commercial herbicides were applied at two levels of treatments each (350ml and 450ml) in replicated trials. Consequently, soil at Beetseh community showed a little decrease in the Electrical Conductivity (EC) and an increase in clay after treatment. The control EC was 485mS and it decreased to the lowest form (224mS) in force-up herbicide at 450ml dose. Control clay value was 6.48% and it increased to 13.20% in Sunphotex herbicide at 450 ml dose. Soil properties at Ucha location community showed a steady decrease in temperature from 26oC (control) to 26oC (450ml Sunphotex). The EC reduced from 457mS (control) to 305 (350ml ForceUp). Clay content increased from the control (4.13%) to 13.41% (Sunphotex at 450ml) with reduced silt level. Soil properties at Ujam location showed a decreased pH from 6.21 in control to 5.64 in Sunphotex at 450ml. Clay content increased from the control (3.2%) to 8.4% in ForceUp and Sunphotex at 450ml each with reduced silt level. Herbicide application affected the soil properties depending on the brand and location. In summary, clay content increased while electrical conductivity, temperature and pH reduced. Alteration was not herbicide specific. The total viable microbial load from the three locations showed an increase microbial load in all the samples after herbicide treatment. Sunphotex yielded the highest average bacterial count of 6×10^{-6} at 450ml. The highest average fungal count was 5×10^{-4} in ForceUp and Uproot at 350ml applications. Although soil parameters were found within the FEPA permissible range, there is need for control and monitoring of rate of herbicide application to maintain the structure and function of the soil for sustainable use.

KEYWORDS

Soil, herbicide, physicochemical, microbial properties, sustainable use

1. INTRODUCTION

Herbicides are one of the major groups of pesticides which provide a tool which man can use to protect the plants (Abid et al., 2000). The use of herbicides in agriculture has over the years contributed tremendously to both food and cash crop production all over the world. The soil serves as the repository for all agricultural contaminants, function as a major habitat for most microbial communities such as soil bacteria, fungi and actinomycetes whose activities influences the soil fertility through organic material degradation, organic matter decomposition and nutrient cycling (Zain et al., 2013). Nonetheless, over application of these chemicals inhibit some of these natural processes and decreases the performance of the non-target organisms (Michael and Stephen, 2016). Soil microorganisms are an important link in soil-plant-herbicide-fauna-man relationships. They take part in herbicide degradation, their activity, number and diversity may serve as bioindicators of changes in soil biological activity following herbicide application.

As farmers continue to realize the usefulness of herbicides, larger quantities are applied to soil. Herbicides could then accumulate to toxic levels in the soil and become harmful to micro-organisms, plants, wildlife and man. There is an increasing concern that herbicides not only affect the

target organisms (weed) but also the microbial community in the soil, and these non-target effects may reduce the performance of important soil functions such as organic matter degradation, the nitrogen cycle and methane oxidation (Hutsch., 2001). Groups of biota such as bacteria, fungi, nematodes, earthworms, termites and protozoa, which may be affected as a result of indiscriminate or incorrect application of herbicides (FAO 2005). The aim of this study was to determine the effects of commonly used herbicides on soil microbial load in three different communities (locations) in Makurdi LGA (Local Government Area) of Benue State, Nigeria.

2. METHODOLOGY

2.1 Description of the Study Area

The study was carried out at Beetseh, Uchaa and Ujam communities (for the field study) in Makurdi Local Government of Benue State. These are host communities of the Joseph Sarwuan Tarka University Makurdi, Benue State. It is located on latitude 7°43 North and longitude 8°28 East and lies in the Guinea savanna vegetation belt of Nigeria. The daily temperature ranges between 25.8°C to 26.3°C with the months of March and August reading the highest temperature. Crops grown include rice, cassava, maize,

Quick Response Code



Access this article online

Website:

www.jsceheritage.com

DOI:

10.26480/gws.012025.45.48

yam etc. Due to the fertile soil of these communities, majority of the people are farmers with few traders and fishermen.

2.2 Study Duration

This study was carried out in the months of September to December 2021

2.3 Herbicide

ForceUp, Uproot and Sunphotex brands of herbicide were used in this study. They were purchased from local agrochemicals dealers in Makurdi town. These herbicides are non-selective foliar-applied, total agricultural herbicide with rapid translocation throughout the plant for the control of most stubborn annual and perennial grasses in arable and plantation crops, under pre-plant, post-emergence directed conditions, reduced or zero tillage systems and they contain Glyphosate as the active ingredient.

2.4 Experimental land size and labeling

Three farm lands each measuring 70m × 70m were used (one in each of the communities) and each was further divided into seven equal parts (10m × 10m) and labeled site 1-7. Site 1 served as control without herbicide application. Site 2, 4 and 6 were treated with the three brands of herbicide at a recommended field rate. Site 3, 5 and 7 were treated with the three brands of herbicide at a rate above recommendation. This procedure was replicated in the three communities.

2.5 Herbicide application

The herbicides were spread on the plots of land (field experiment) and directly on the soil samples in polythene bags (for laboratory experiment) using a knapsack sprayer at the following concentration. Exactly 350ml (recommended field rate) was diluted in 15litres of water and spread on the plot labelled Site 2, 4 and 6 (Sebiomo et al., 2011). Exactly 450ml (rate above recommendation) was diluted in 15litres of water and spread on the plot labelled Site 3, 5 and 7. This was done to test effects since farmers sometimes use higher concentrations in the bid to get quick results. Site 1 soil samples served as control for each location therefore its comparison with herbicide application to each soil measured the effect of herbicides on microbial population (Parions et al., 2003).

2.6 Field sample collection

Five kilograms (5kg) of soil samples were collected randomly from the upper 10cm of the soil profile without herbicide application from the experimental plots (site 1) as control samples from the three communities (Beetseh, Ucha and Ujam) with soil auger (one from each community making a total of three control samples) (Lal and Saxena, 1982). After two weeks of herbicides application, eighteen (from site 2-6) other soil samples (six from each community) were collected making a total of twenty-one (21) samples.

2.7 Physicochemical characterization of soil samples

The physicochemical parameters for this work include colour, texture, pH, temperature and electrical conductivity. The temperature and colour of the samples were recorded on the spot of sample collection using soil thermometer and Muncel-colour book respectively while pH and electrical conductivity were measured according to standard procedure as given below. Exactly 100ml of distilled water was added to 10g of air-dry soil to prepare a suspension. The pH and electrical conductivity of the soil were measured and recorded from the suspension using pH metre and conductivity metre respectively. Soil conductivity reading was taken in milli-Siemens (mS). (Anand and Sadhana, 2014). The soil texture was determined using Hydrometer method. The soil was soaked with sodium hexametaphosphate solution on an orbital shaker overnight and transferred to a one litre graduated cylinders and filled with water. The solution was further mixed with a metal plunger to disperse the soil particles and measurements were taken using the soil hydrometer which was lowered into the cylinders containing the solutions at different times; 45s for sand and 1 hour 30 minutes for silt and 6hrs for clay.

2.8 Microbiological analysis of soil samples

Microbiological analysis of soil was made for the enumeration of micro-fungal and bacterial population using Dilution plate count technique (DPCT). The primary suspension of the soil was prepared from 1g of soil which was diluted up to 10⁻⁹ time using sterile water as diluting fluid (Haney et al., 2000).

2.9 Bacterial enumeration

For the enumeration of bacterial population, 1ml of aliquots from 10⁻⁶ diluted suspension was transferred to petri dishes and 25ml of molten nutrient agar medium was added. After an incubation period of 48 hours, total viable colony on each plate was counted using colony counter and the data were recorded accordingly (Aroh et al., 2018). For the isolation of pure culture, each typical colony was further sub cultured for further identification with MacConkey agar. The bacterial isolates were identified through biochemical test (using Gram reaction, Cell shape, Motility, Colony pigmentation, Oxidase and Catalase test and Indole production test) with the aid of atlas for microbiology laboratory (Michael and Burton, 2011).

2.10 Fungal enumeration

Exactly 1ml of aliquots from 10⁻⁴ diluted suspension was transferred to petri dishes and to it 25ml of molten agar-Potatoes Dextrose Agar (PDA) supplemented with streptomycin to inhibit bacterial growth was poured, swirled and incubated (Axelrade et al., 2003). After 14 days incubation at the temperature of 28°C, Viable colonies were counted. The fungal morphology was studied macroscopically by observing colony features (colour and texture) and microscopically by staining (Axelrade et al., 2003).

2.11 Staining technique for fungi

With the aid of inoculating needle, a small portion of the growth on the culture plate was transferred into the drop of Lactophenol in cotton blue on the slide. The specimen was teased carefully using inoculating needle to avoid squashing and over-crowding of the mycelium. The specimen was observed under the microscope for identification with the aid of atlas for microbiology laboratory (Michael and Burton, 2011).

3. DATA ANALYSIS

Descriptive statistics were used to analyze the data collected from this study using the statistical tool of the SPSS. Results were compared with the permissible limits of FEPA (Federal Environmental Protection Agency)

4. RESULTS

4.1 Effect of herbicide application on physicochemical properties of soil

The Physicochemical Parameters of soil samples from Beetseh community (table 1) showed a little decrease in the Electrical Conductivity (EC) and an increase in clay after treatment. The control EC was 485mS and it decreased to the lowest form (224mS) in force-up herbicide at 450ml dose. Control clay value was 6.48% and it increased to 13.20% in Sunphotex herbicide at 450 ml dose. All physicochemical parameters were found within within the FEPA permissible range.

The Physicochemical parameters of soil samples at Ucha location (table 2) showed a steady decrease in temperature from 26°C (control) to 26°C (450ml Sunphotex). The EC reduced from 457mS (control) to 305 (350ml ForceUp). Clay content increased from the control (4.13%) to 13.41% (Sunphotex at 450ml) with reduced silt level. All physicochemical parameters were found within the FEPA permissible range. The Physicochemical parameters of soil samples at Ujam location (table 3) showed a decreased pH from 6.21 in control to 5.64 in Sunphotex at 450ml. Clay content increased from the control (3.2%) to 8.4% in ForceUp and Sunphotex at 450ml each with reduced silt level. All physicochemical parameters were found within the FEPA permissible range.

Table 1: Physicochemical parameters of soil samples from Beetseh

Site	Herbicide	Concentration	Temp	Colour	pH	E.C (mS)	% Sand	% Clay	% Silt
1	Control	0ml	25.70	Brown	5.52	485	74.24	6.48	19.28
2	ForceUp	350ml	25.60	Brown	5.73	286	79.52	8.48	12.00
3	ForceUp	450ml	24.90	Brown	5.74	224	77.52	11.20	11.28
4	Uproot	350ml	25.80	Brown	5.66	229	74.80	11.92	13.28
5	Uproot	450ml	25.90	Dark brown	5.53	394	77.52	9.20	13.28
6	Sunphotex	350ml	25.20	Brown	5.46	404	77.52	9.20	13.28
7	Sunphotex	450ml	25.40	Dark brown	5.30	370	74.24	13.20	12.56
	FEPA		20-30	None	6.5-8.5	1000	Sandy	Clay-	Silt

Key: E.C: Electrical Conductivity; FEPA: Federal Environmental Protection Agency

Table 2: Physicochemical parameters of soil samples from Ucha									
Site	Herbicide	Concentration	Temp	Colour	pH	E.C	% Sand	% Clay	% Silt
1	Control	0ml	26.0	Dark brown	5.82	457	75.62	4.13	20.25
2	ForceUp	350ml	25.9	Brown	5.75	305	75.59	5.80	18.61
3	ForceUp	450ml	25.6	Brown	5.85	422	73.68	6.52	19.80
4	Uproot	350ml	25.9	Dark brown	5.82	293	73.93	11.15	14.92
5	Uproot	450ml	26.1	Dark brown	5.68	360	74.13	12.11	13.76
6	Sunphotex	350ml	25.2	Dark brown	5.72	410	75.24	9.94	14.82
7	Sunphotex	450ml	24.8	Dark brown	5.88	386	72.17	13.41	14.42
	FEPA		20-30	None	6.5-8.5	1000	Sandy	Clay	Silt

Key: E.C: Electrical Conductivity

Table 3: Physicochemical parameters of soil samples from Ujam									
Site	Herbicide	Concentration	Temp (°C)	Colour	pH	E.C (mS)	% Sand	% Clay	% Silt
1	Control	0ml	26.2	Reddish brown	6.21	345	74.24	3.2	22.56
2	ForceUp	350ml	26.2	Dark brown	5.98	256	72.80	6.48	20.72
3	ForceUp	450ml	26.1	Dark brown	5.77	344	78.24	8.48	13.28
4	Uproot	350ml	25.3	Reddish brown	6.12	218	77.52	4.48	18.00
5	Uproot	450ml	26.0	Dark brown	5.88	376	75.52	5.20	19.28
6	Sunphotex	350ml	25.8	Brown	5.97	218	79.52	7.20	13.28
7	Sunphotex	450ml	25.9	Dark brown	5.64	389	71.52	8.48	20.00
	FEPA		20-30	None	6.5-8.5	1000	Sandy-	Clay-	Silt

Key: E.C: Electrical Conductivity.

4.2 Effect of herbicide application on microbial load of soil

The total viable count of bacteria from the three locations (table 4) showed an increase bacterial count in all the samples after herbicide treatment.

Sunphotex yielded the highest average count of 6×10^{-6} and 5.5×10^{-6} at 450ml and 350ml respectively whereas the average control value was 3.1×10^{-6} . The total count of fungi from the three locations (table 5) showed an increase in fungal count in all the samples after herbicide treatment. The highest average count recorded was 5×10^{-4} in ForceUp and Uproot at 350ml whereas the average control value was 4.2×10^{-4} .

Table 4: Total Viable Count of Bacteria in Soi						
Site	Herbicide	Concentration	Location		Average count (10 ⁻⁶)	
			Ujam (10 ⁻⁶)	Beetseh (10 ⁻⁶)	Ucha (10 ⁻⁶)	
1	Control	0ml	2.8	3.4	3.1	3.1
2	ForceUp	350ml	3.6	3.1	5.2	4.0
3	ForceUp	450ml	2.9	7.5	5.8	5.4
4	Uproot	350ml	5.0	6.8	3.8	5.2
5	Uproot	450ml	6.1	6.3	3.2	5.2
6	Sunphotex	350ml	5.7	4.8	6.1	5.5
7	Sunphotex	450ml	8.1	5.1	4.9	6.0

Table 5: Total Viable Count of Fungi in Soil						
Site	Herbicide	Concentration	Location		Average fungal count (10 ⁻⁴)	
			Ujam (10 ⁻⁴)	Beetseh (10 ⁻⁴)	Ucha (10 ⁻⁴)	
1	Control	0ml	4.0	4.2	4.5	4.2
2	ForceUp	350ml	5.2	4.9	4.8	5.0
3	ForceUp	450ml	4.2	4.6	5.4	4.7
4	Uproot	350ml	4.1	6.2	4.7	5.0
5	Uproot	450ml	4.5	4.3	3.9	4.2
6	Sunphotex	350ml	4.9	4.5	4.5	4.6
7	Sunphotex	450ml	4.7	5.1	4.2	4.7

5. DISCUSSION

Outcome of the physicochemical analysis showed normal parameters within FEPA (Federal Environmental Protection Agency) permissible range under the doses applied on soil. However, slight alterations in soil properties were observed. There was an increase in the percentage sand and clay. However, the silt (loam) which serves as habitat for most micro-organisms and a major reservoir of nutrients for plants uptake decreased after treatment. This shows that herbicides when constantly used on a particular farm land over a long period may cause the depletion of soil nutrient since they contain heavy metals that immobilize nutrients from the soil (Ali et al., 2019). Decreased soil acidity (from strongly acidic to moderately acidic) was also noticed in most of the samples. However, the temperature, electrical conductivity, pH and soil colour remained fairly constant and in compliance with the FEPA's guidelines indicating that herbicides do not have a short term impact on the colour and temperature of the soil.

In the study, it was discovered that the three brands of herbicides had a positive influence on bacterial and fungal load in the field. This could be due the impact of surface runoff and the activities of macro-organisms (earthworms, snails, millipedes) reported to affect the concentration and degradation of herbicides (Dicks, 2013). It was also discovered that Sunphotex at all levels yielded the highest average bacterial count while ForceUp and Uproot at 350ml yielded the highest fungal count. The mean fungal isolates witnessed a steady increase as treatments increases. This is because most fungal species benefit from herbicides application (Michael et al., 2016). This could be as a result of the concentration of glyphosate in the brands. Results suggest the ability of micro-organisms like *Bacillus* spp and *pseudomonas* spp to breakdown some aspects of the herbicides to use it as source of carbon for growth and multiplication (Sebiomo et al., 2011). Results are in tandem that the biotic and abiotic oxidative degradation of materials caused breakage of both the C-P and C-N bonds thereby releasing Carbon, Phosphorus and Nitrogen as essential nutrients for microbial activities (Mulyowidarmo 2018).

6. CONCLUSION

Herbicide application slightly affected the soil properties depending on the brand and location. In summary, clay content increased while electrical conductivity, temperature and pH reduced. Alteration was not herbicide specific. The total viable microbial load from the three locations showed an increase microbial load in all the samples after herbicide treatment. Sunphotex yielded the highest average bacterial count of 6×10^6 at 450ml. The highest average fungal count was 5×10^4 in ForceUp and Uproot at 350ml applications. Although soil parameters were found within the FEPA permissible range, there is need for control and monitoring of rate of herbicide application to protect the structure and function of the soil.

REFERENCES

- Abid, S., Ayman, M. E., Huang, C., and Xu, J. 2000. Effects of pesticides (herbicides) on soil microbial biomass. *Pakistan Journal of Biological Sciences*, 3(5), Pp. 705–709.
- Ali, H., Khan, E., and Ilahi, I. 2019. Environmental chemistry and ecotoxicology of hazardous heavy metals: Environmental persistence, toxicity, and bioaccumulation. *Journal of Chemistry*, 2019 (4), Pp. 1–14.
- Anand, D. G., and Sadhana, C. 2014. A handbook of water, air and soil analysis (A lab manual). International E-publication.
- Aroh, B., Adeleye, I. A., and Osidipo, O. O. 2018. Isolation and characterization of microorganisms from instruments used in pedicurists operating within larger metropolis. *West Industrial Medical Journal*, 53, Pp. 413–415.
- Axelrade, J. C., Howard, C. V., and McLean, W. G. 2003. The effects of acute pesticide exposure on neuroblastoma cells chronically exposed to diazinon. *Toxicology*, 18(1), Pp. 67–78.
- Dicks, L. 2013. Bees, lies and evidence-based policy. *Nature*, 494(7437), 283.
- Haney, R. L., Senseman, S. A., Hons, F. M., and Zuberer, D. A. 2000. Effect of glyphosate on soil microbial activity and biomass. *Weed Science*, 48, Pp. 89–93.
- Hutsch, B. W. 2001. Methane oxidation in non-flooded soils as affected by crop production. *European Journal of Agronomy*, 14, Pp. 237–260.
- Lal, R., and Saxena, D. M. 1982. Accumulation, metabolism and effects of organochlorine insecticides on microorganisms. *Microbial Review*, 46(4), Pp.95–96.
- Michael, J. L., and Burton, E. P. 2011. A photographic atlas for the microbiology laboratory (4th ed.). Morton Publishing.
- Michael, O. A., and Stephen, A. 2016. Effect of some commonly used herbicides on soil microbial population. *Journal of Environment and Earth Science*, 6(1), Pp. 6–11.
- Mulyowidarso, R. K., Fleet, G. H., and Buckle, K. A. 2018. The microbial ecology of soybean soaking for tempe production. *International Journal of Food Microbiology*, 8, Pp. 35–46.
- Parions, W., Fredericksen, T. S., and Licons, J. C. 2003. Natural regeneration and liberation of timber species in logging gaps in two Bolivian tropical forests. *Forest Ecology and Management*, 181(3), Pp. 313–322.
- Sebiomo, A., Ogundero, V. W., and Bankole, S. A. 2011. Effects of four herbicides on microbial population, soil organic matter and dehydrogenase activity. *African Journal of Biotechnology*, 10(5), Pp. 770–778.
- Zain, N. M. M., Mohamad, R. B., Sijam, K., Morshed, M. M., and Awang, Y. 2013. Effects of selected herbicides on soil microbial populations in oil palm plantation of Malaysia: A microcosm experiment. *African Journal of Microbiology Research*, 7(5), Pp. 367–374.

