International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Assessment of Volatile Organic Compound (VOC) Emissions During Farmland Tillage Operations: Influence of Tractor Models and Speeds

[1*]Bankole, Yakub O; [1]Odunukan, Risikat O; [2]Lamidi Sheriff B; [1]Tanimola A. Olanrewaju
[1]Department of Agricultural and Bio- Environmental Engineering, Lagos State University of Science and Technology Ikorodu. Lagos State, Nigeria.
[2]Department of Mechanical Engineering Lagos State University of Science and Technology Ikorodu. Lagos State, Nigeria.
*CORRESPONDENCE AUTHOR: Bankole, Yakub O, Wale_yaksbankole@yahoo.com

Abstract— *Agricultural mechanization plays a crucial role in modern farming, but tractor emissions pose environmental concerns. This study assesses volatile organic compound (VOC) emissions from different tractor models (New Holland (NH) and Massey Ferguson (MF), both old and new) to make a total of four tractors otherwise tagged as T_1, T_2, T3 and T_4, and operating at varying speeds (15 km/h, 20 km/h, and 24 km/h) during tillage operations. The experiment was conducted on a 14.4-hectare farmland at Lagos State University of Science and Technology, Ikorodu, Nigeria, with sandy-loamy soil. VOC emissions were measured using the Multireal Pro Handheld Gas Analyzer before, during, and after tillage operations. Tractors were classified based on model and usage hours, with those exceeding 5,000 hours classified as old and those below as new. The research involved different tillage speeds and operations, with data collected from 50-meter by 10-meter mapped plots. VOC emission levels varied significantly with tractor speed and model. The highest emissions were recorded at 20 km/h, particularly during ridging and first ploughing. At 24 km/h, emissions across operations remained relatively constant, while harrowing exhibited the lowest VOC emissions. Older tractors (NH old and MF old) emitted higher VOC levels than newer models, with NH old recording the highest emissions at 20 km/h. The study highlights the influence of tractor model, age, and speed on VOC emissions, with 20 km/h producing the highest rates. Proper tractor maintenance, optimized speed selection, and reduced tillage intensity can help mitigate emissions in sustainable agriculture.*

Keywords— *VOC emissions, tractor models, tillage speed, agricultural mechanization, environmental impact.*

I. Introduction

Agriculture is a fundamental sector that sustains human life by providing food and raw materials. However, its practices significantly contribute to environmental degradation, including air pollution. One major environmental concern in modern agriculture is the emission of Volatile Organic Compounds (VOCs) during tillage operations. VOCs are organic chemicals that easily evaporate into the atmosphere, contributing to air pollution and forming secondary pollutants like ozone and particulate matter, which adversely affect human health and the environment [1,2].

Tillage, a critical agricultural process for preparing soil and optimizing crop yields, is an energy-intensive operation requiring substantial fuel consumption. Primary tillage activities, such as plowing, break compact soil layers, while secondary tillage operations, such as harrowing and ridging, though less energy-intensive, also contribute to VOC emissions [2-4]. VOCs are released during these activities as by-products of fuel combustion in agricultural machinery, with emission levels influenced by factors such as tractor model, engine efficiency, and operational parameters like speed [5,6].

The type and model of tractors used play a vital role in determining the volume and composition of VOC emissions. Older tractors, often equipped with outdated engines and lacking emission control systems, tend to release higher VOC levels compared to modern tractors that comply with stringent environmental standards [7]. Modern tractors are designed to be more efficient and environmentally friendly, yet their actual VOC emissions under varying tillage conditions remain under-explored [8,9].

Operational speed is another critical factor influencing VOC emissions. Higher tractor speeds typically lead to increased engine revolutions per minute (RPM), greater fuel consumption, and incomplete combustion processes, thereby amplifying VOC release [9-11]. Conversely, lower speeds may reduce emissions but can compromise operational efficiency. Understanding the interplay between tractor models and speeds is essential for evaluating the environmental footprint of agricultural mechanization [12-14].

The urgency to mitigate VOC emissions in agricultural practices aligns with global efforts to combat climate change and achieve sustainable development goals. While emissions from industrial and urban sources have been extensively studied, research focusing on agricultural VOC emissions, particularly during tillage operations, remains limited [15]. This study seeks to bridge this gap by assessing VOC emissions across different tractor models and operational speeds during primary and secondary tillage activities [11,16,17].

By understanding emission patterns and identifying sustainable practices, this research aims to inform policies that reduce the environmental impact of agricultural mechanization. The findings will provide valuable insights for farmers, policymakers, and researchers, guiding the balance between agricultural productivity and environmental stewardship. This work underscores the importance of promoting sustainable agricultural practices to mitigate environmental impacts and supports the global agenda for sustainable development.

Bankole, Yakub O; Odunukan, Risikat O; Lamidi Sheriff B; and Tanimola A. Olanrewaju, "Assessment of Volatile Organic Compound (VOC) Emissions During Farmland Tillage Operations: Influence of Tractor Models and Speeds," *International Research Journal of Advanced Engineering and Science*, Volume 10, Issue 2, pp. 24-27, 2025.

International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

II. Research Methods And Methology

This study was conducted at Lagos State University of Science and Technology (formerly Lagos State Polytechnic), Ikorodu, Nigeria, within the western vegetation zone on sandy-loamy soil. The study area is geographically located at 16°37'0" North and 3°37'0" East, covering 14.4 hectares of land. The tools and equipment used included measuring tapes, ranging poles, tractors (New Holland and Massey Ferguson, both new and old models), hand-held gas analyzers (Multireal Pro), disc ploughs, disc harrows, ridgers, soil thermometers, soil core samplers, ropes, nylon bags, rulers, trowels, pegs, and ranging poles. These were essential for soil measurement, data collection, and VOC emission monitoring.

The tractors were rated based on model and usage hours, with two brands, New Holland and Massey Ferguson, used. Tractors with less than 5,000 hours of usage were classified as new, while those with over 5,000 hours were classified as old. This classification was necessary for evaluating the influence of tractor age on VOC emissions. The key experimental variables included Tractor Age (new or old), Tractor Model (New Holland or Massey Ferguson), and Tillage Speed (15 km/h, 20 km/h, and 24 km/h). These variables were systematically combined across experimental runs to assess their effects on VOC emissions.

The 14.4-hectare experimental field was measured and mapped into a 400-meter by 360-meter area, further divided into 50-meter by 10-meter plots. These plots were assigned to different tractor models operating at various speeds. VOC emissions were recorded using the Multireal Pro Handheld Gas Analyzer before, during, and after each operation. The experiment was conducted under controlled conditions to ensure accuracy and reliability in VOC emission measurements.

III. Results And Discussion

TABLE 1: Effect of tillage operation and tractor model on Volatile organic compound emission

	Tractor 1	Tractor 2	Tractor 3	Tractor 4
1st plough	11.86	17.56	12.41	18.77
2nd plough	11.02	15.75	11.47	16.75
Harrowing	13.20	9.33	14.70	12.55
Ridging	12.22	18.08	12.78	19.33

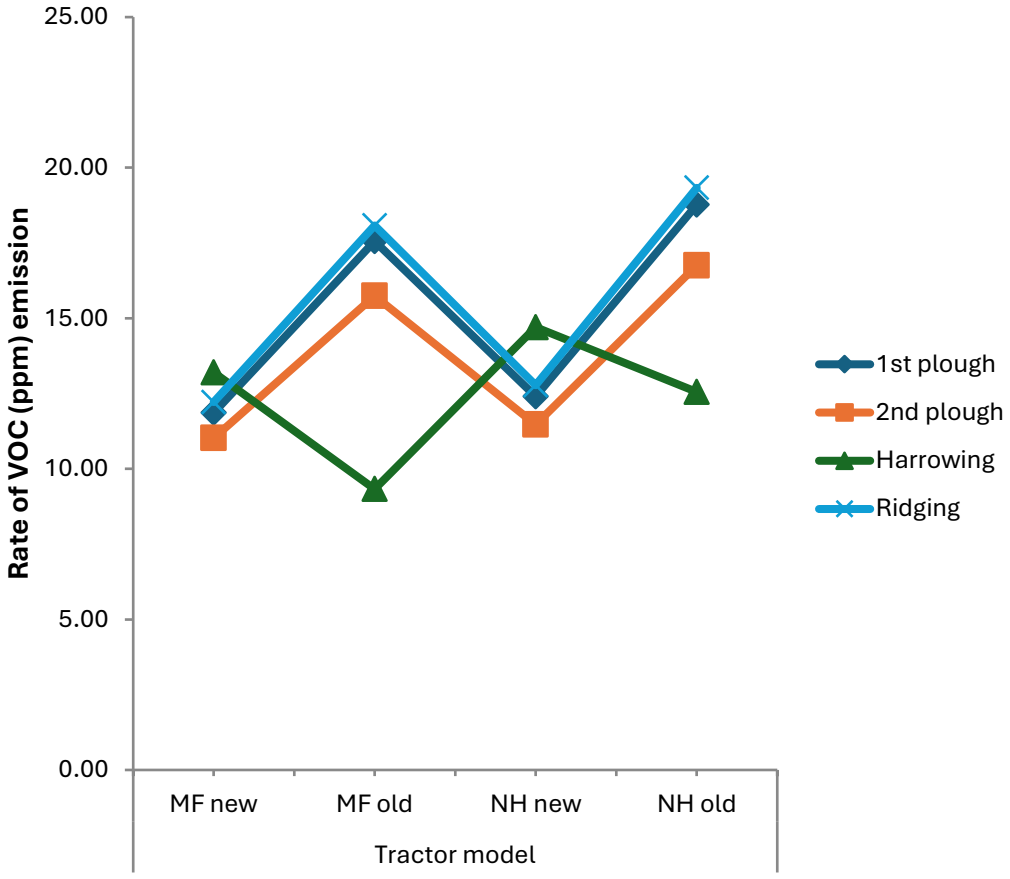

Figure 1: Effect of tillage operation and tractor model on volatile organic compound emission

Bankole, Yakub O; Odunukan, Risikat O; Lamidi Sheriff B; and Tanimola A. Olanrewaju, "Assessment of Volatile Organic Compound (VOC) Emissions During Farmland Tillage Operations: Influence of Tractor Models and Speeds," *International Research Journal of Advanced Engineering and Science*, Volume 10, Issue 2, pp. 24-27, 2025.

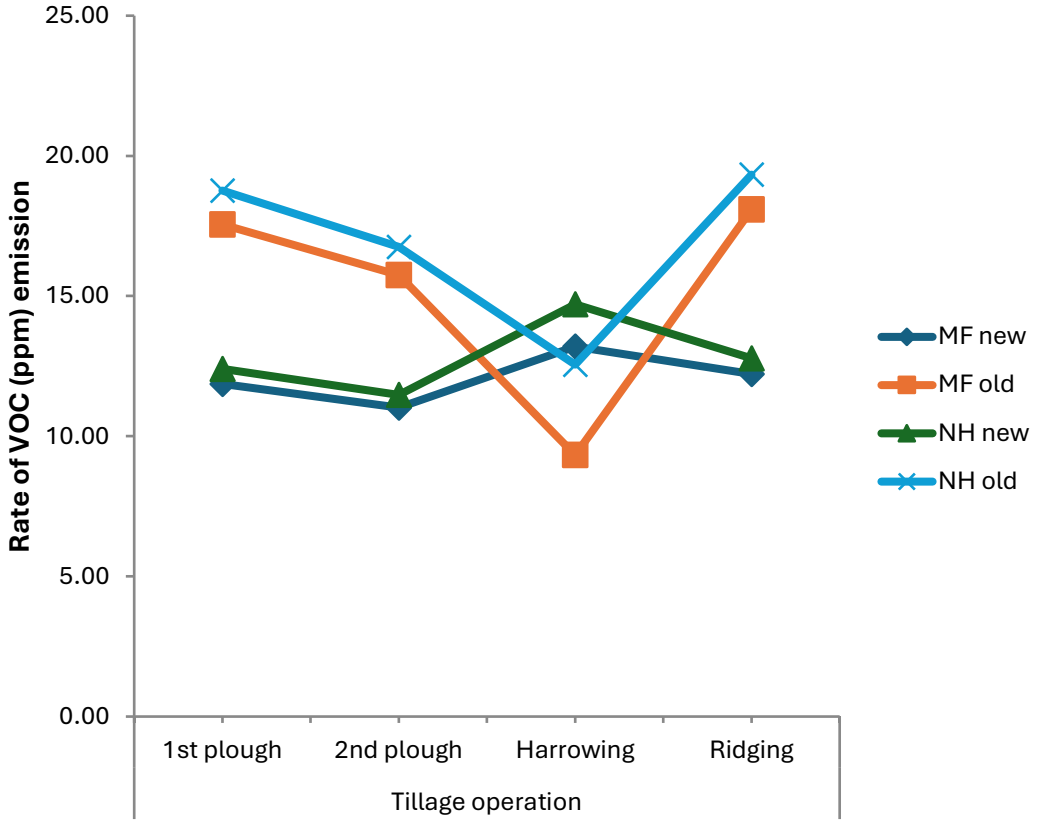

Figure 2: Effect of tillage operation and tractor model on volatile organic compound emission

Effect of tillage operation and tractor model on Volatile Organic Compounds (VOC) gas emission

From figure 1 and 2, T_4 (NH, old) produces the maximum VOC emission during ridging while T_2 (MF, old) produces the lowest VOC emission rate during harrowing. During harrowing, VOC emission is always very low with tractor models T_4 (New Holland, old) and T_2 (MF, old). 1st plough, 2nd plough and ridging have the same VOC emission rate using tractor model T_3 (NH, new) and T_1 (MF, new). T_3 (NF, new) and T_1 (MF, new) produce high emission of VOC during harrowing. Tractor model T_3 (NH, new) and T_1 (MF, new) models have the same emission pattern across the four tillage operations. From the result table 1, it was observed that VOC had higher values recorded for all tillage operations using T_2 (MF, old) and T_4 (NH, old) tractor, with ridging operation using T_4 (NH, old) having the highest recorded value of 19.33. Harrowing operation carried out using tractor T_2 (MF, old) had the least recorded value of 9.33.There are no significant differences in the quantities of VOC generated under the following combination of tillage operation types and models of tractor: first ploughing using T_1 (MF, new), first ploughing using T_3 (NH, new), harrowing using T_4 (NH, old) and ridging using T_1 (MF, new); first ploughing using T_1 (MF, new), second ploughing using T_3 (NH, new) and ridging using T_1 (MF, new); first ploughing using T_2 (MF, old) and ridging using T_2 (MF, old); first ploughing using T_1 (MF, new), harrowing using T_4 (NH, old), ridging using T_1 (MF, new) and ridging using T_3 (NH, new); first ploughing using T_4 (NH, old) and ridging using T_4 (NH, old); first ploughing using T_4 (NH, old) and ridging using T_2 (MF, old) second ploughing using T_1 (MF, new) and second ploughing using T_3 (NH, new); harrowing using T_1 (MF, new), harrowing using T_4 (NewHolland, old) and ridging using T_3 (NewHolland, new). However, there are significant differences in the amounts of VOC generated at second harrowing using T_2 (MF, old) and T_4 (NH, old), and harrowing using T_2 (MF, old) and T_3 (NH, new).

IV. Conclusion

In terms of tractor models, NH old consistently showed the highest VOC emissions, particularly during ridging, whereas MF old had the lowest emissions during harrowing. NH new and MF new followed a similar emission pattern, especially at higher speeds where emission differences between tractor models became less significant. Overall, the study highlights the need for strategic tillage management to minimize VOC emissions. Selecting appropriate tractor models and optimizing operating speeds can contribute to lower emissions while maintaining efficiency in field operations. Future research should explore emission-reducing technologies and sustainable tillage practices to mitigate the environmental impact of agricultural machinery.

References

1. Kim, W.-S., Baek, S.-M., Baek, S.-Y., et al. (2024). *Evaluation of exhaust emissions of agricultural tractors using portable emissions measurement system in Korean paddy field*. *Scientific Reports*, 14(1). arxiv.org+12pubs.acs.org+12pubmed.ncbi.nlm.nih.gov+12
2. Li, H., Chen, Y., Zhang, F., et al. (2023). *Real-World Emission Characteristics of Full-Volatility Organics Originating from Nonroad*

Agricultural Machinery during Agricultural Activities. *Environmental Science & Technology*, 57(28), 10308–10318. pubs.acs.org+1pubs.acs.org+1

3. Wang, D., Cheng, Z., Xu, B., Zhang, B., & Li, J. (2022). *Intermediate-Volatility Organic Compound Emissions from Nonroad Construction Machinery under Different Operation Modes*. *Environmental Science & Technology*, 56(20), 14262–14271. pubs.acs.org
4. Lee, J., Son, M., & Gwon, H. (2022). *Development and Validation of Prediction Model for Exhaust Emissions During Tractor Plow Tillage*. *Agriculture*, 14(12), 2334. mdpi.com+13mdpi.com+13mdpi.com+13
5. Lovarelli, D., Cangemi, M., Mola, A., & Bacenetti, J. (2021). *Analysis of Air Pollutant Emission Inventory from Farm Tractor Operations in Korea*. *Emissions*, 11(1), 17. pubs.acs.org+2mdpi.com+2reddit.com+2
6. Smith, A. F., & Zhao, L. (2022). *Soil carbon sequestration, greenhouse gas emissions, and water pollution under different tillage practices*. *Science of The Total Environment*, 826, 154161. sciencedirect.com
7. Zhang, Y., Zhu, Z., Zheng, Y., Chen, Y., Yin, F., Zhang, W., & Dong, H. (2019). *Characterization of VOC Emissions from Swine Manure Biogas Digestate Storage*. *Atmosphere*, 10(7), 411. pubs.acs.org+3mdpi.com+3reddit.com+3
8. Tang, T., Cheng, Z., Xu, B., et al. (2022). *Source Diversity of Intermediate Volatility n-Alkanes Revealed by Compound-Specific δ^13C–δD Isotopes*. *Environmental Science & Technology*, 56(20), 14262–14271. pubs.acs.org
9. EPA & FAO (2024). *Volatile Organic Compounds in Agricultural Pollution*. In *Agricultural Pollution Review*. (Updated summary on VOC contribution from tillage practices.)
10. Farag, M. A., Fokar, M., & Allen, R. D. (2017). *Myrcene as a Natural Base Chemical in Sustainable Chemistry: A Critical Review*. *ChemSusChem*. (Background on VOC behavior in environmental contexts.)
11. Bankole, Yakub O, Tanimola Olanrewaju A, Saliu Bilikis O, Odunukan Risikat O, Dare Bisola T, Ajisegiri Emanuel S.A. & Lamidi Sheriff B. (2022). Environmental Impact Of Tillage Operations And Tractor Speed On Hydrogen Sulphide (H_2S) Gas Emission. Proceedings of the LASUSTECH 30th iSTEAMS Multidisciplinary Innovations Conference, 2022 Series 30 Vol 2.
12. Bavilinezhad, S., Najafi, M., Kaushal, V., Elledge, W., & Kaynak, B. (2024). Environmental Impact Assessment of Volatile Organic Compound Emissions during Trenchless Cured-in-Place Pipe Installation. *Environments*, *11*(8), 169. https://doi.org/10.3390/environments11080169.
13. Bavilinezhad, S.; Elledge, W.; Kaynak, B.; Najafi, M.; Sattler, M.; Kaushal, V.; Hamidzadeh, P. (2024). Preliminary Results of Measuring Volatile Organic Compound Emissions during Cured-in-Place Pipe (CIPP) Renewal. In Proceedings of the No-Dig Show, 2024 Conference, Providence, RI, USA, 14–18. [Google Scholar].
14. European Union. Directive 2010/75/EU of the European Parliamentand of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control). Accessed via EUR-Lex(https://eur-lex.europa.eu/homepage.html) on 31st May, 2023.
15. Hamid, A. (2024). Comparison of three primary tillage Plows commonly used in Iraq. Kirkuk University Journal For Agricultural Sciences, 15(2),260-269. doi: 10.58928/kujas.2024.149727.1169.
16. Indelicato, S. et al. Effect of solid waste landfill organic pollutants on groundwater in three areas of Sicily (Italy) characterized by different vulnerability. Environ. Sci. Pollut. Res. 24, 16869–16882 (2017).
17. Kutzbach, H. D., Bernhardt, H., & Frühwirth, J. (2016). Fuel consumption and emissions during agricultural field operations. *Journal of Agricultural Engineering Research*, 12(3), 143–155.