



ZIBELINE INTERNATIONAL™
P U B L I S H I N G
ISSN: 2805-5063 (Online)
CODEN: PPSCCU

Plant Physiology and Soil Chemistry (PPSC)

DOI: <http://doi.org/10.26480/ppsc.01.2025.08.10>



RESEARCH ARTICLE

PESTICIDE APPLICATION, AN INVESTIGATION TOWARDS THREAT TO SOIL MICROORGANISMS IN CHITWAN DISTRICT OF NEPAL

Prava Dawadi, Janak Pant*

Department of Entomology, Agriculture and Forestry University, Chitwan, (44209) Rampur, Chitwan, Bharatpur municipality, Nepal.

*Corresponding Author Email: janakpant500@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 09 October 2024
Revised 25 November 2024
Accepted 30 December 2024
Available online 17 January 2025

ABSTRACT

In the Chitwan district the study of pesticide effects at different temperatures in soil microorganisms have not been carried. So, an experiment to determine the threat of pesticide in different types of soil microorganisms were carried out at variable environmental factors. The study was carried out in November 2022 to December 2022 in the Department of Entomology, Agriculture and Forestry University (AFU), Chitwan, Nepal. The contamination and threat of soil were determined by collecting variable soil samples. 10 soil samples were collected from different and alternative parts of the study area. Soil samples were selected from farmers' fields and fallow lands. Soil microorganisms such as *Azospirillum brasilense*, *Azotobacter chroococcum* and *Pseudomonas sp.* have pesticide residues of Methidathion, Simazine and Metsulfuron methyl with effect in nitrogen fixation and growth of respective microorganisms. The effect of higher temperature (40°C) has peak activity in *Azospirillum brasilense*, *Azotobacter chroococcum*, *Azospirillum brasilense* and *Pseudomonas sp.* Therefore, it was clear that large pesticides have residual effects in soil microorganisms while environmental factors have detrimental effects in soil microorganisms in Chitwan district of Nepal.

KEYWORDS

Herbicide, Insecticides, Microorganism, Residues, Soil, Temperature

1. INTRODUCTION

Microorganisms fulfil a wide range of ecosystem functions in soil such as the release of nutrients from minerals and organic matter and N₂ fixation (Krishna and Mohan, 2017; Gadd, 2007; Uroz et al., 2009; Vitousek et al., 2002). Accordingly, a larger soil microbial biomass has higher potential in fulfilling these functions. Soil contains millions of microbes involved in soil fertility betterment and crop production (Gougoulias et al., 2014). Numerous benefits of beneficial microorganisms exist, such as bacteria and fungi, influencing the soil and providing suitable environment for the development of plants (Ortiz and Sansinenea, 2021). The beneficial relationship of these microbes with the plants includes the nutrients distribution to crops, plant growth stimulation, producing phytohormones, biocontrol of phytopathogens, improvement soil structure, bioaccumulation of inorganic compounds, and bioremediation of metal-contaminated soils. To improve plant growth microorganisms, play several vital roles (Prakash and Mishra, 2022; Khan et al., 2020).

The influence of pesticides on soil microorganisms is dependent on physical, chemical, and biochemical conditions, in addition to nature and concentration of the pesticides. Some microorganisms living in soil are known to be detoxification agents of pesticides, although pesticides may have a degree of persistence despite the same microorganisms. That may be due to the difference in physio-chemical properties of soils and also the environmental factors such as pH, moisture content and temperature as well (Abdel-Rahman, 1999). Soil may be affected by fluctuation of various kinds of environmental factors such as temperature (Chen et al., 2020; Byrne, 2021). Multi-factors which are both seen and unseen responsible to influence soil microorganisms and their types. The detrimental effect of pesticides on the species composition of microorganism's triggers changes in higher trophic levels. This modification involves both qualitative and quantitative changes (Ahlgren et al., 1990).

In a survey in 2019, maximum application of chemicals (such as pesticides and antibiotics) determined as the huge impacting mechanism that have resulted in loss of soil fauna, biodiversity, and fertility over 10 years (FAO, 2020). The soil diversity provides a wide range of ecosystem services and influences ecosystem multifunctionality pesticides have detrimental effect on the beneficial soil fauna's and affecting soil health, impacting agricultural production and productivity (Russell et al., 2024; Chenguang Gao et al., 2024; Philipp Mäder et al., 2024). Pesticides have long term negative consequences in soil, environment, and human health. Pesticide application in Nepal has been increasing with the annual import going from 404 tons in 2012 to 635 tons in 2018 (CBS, 2019).

The number of households using pesticides varies considerably across the country, with the Terai (plains) region having the highest users (25.04% of land holdings) and the Mountains region having the least at about 7.14% of land holdings (CBS, 2003). In general, the effects of pesticides on microorganisms will vary depending on the chemical dosage, the properties of the soil and various environmental factors (Ecobichon, 1991). Several soil microbial enzymes are hampered or affected by the application of pesticides to the soil (Kalia and Gosal, 2011). The study is concerned with the contamination of pesticides in the soil microorganisms and its effect in soil at different temperatures in Chitwan district of Nepal.

2. MATERIALS AND METHODS

The contamination and threat of soil were determined by collecting variable soil samples. The study was carried in November 2022 to December 2022 in Chitwan district of Nepal. 10 soil samples were collected from different and alternative parts of the district. Soil samples were selected from farmers' fields and fallow lands. Laboratory study in Department of Entomology, Agriculture Forestry University, Chitwan was carried for each sample of soil collected. The study was determined at variable temperature situations of the soil sample.

Quick Response Code



Access this article online

Website:
www.ppsc.org.my

DOI:
[10.26480/ppsc.01.2025.08.10](https://doi.org/10.26480/ppsc.01.2025.08.10)

The recorded data were all tabulated and systematically arranged using MS- Excel which were subjected to Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT-0.05 level) for mean separations using Gen stat software.

3. RESULT AND DISCUSSION

3.1 Pesticides residues in soil samples (microorganisms) and their effects

Pesticides	Organisms	Effects
Bromopropylate (I)*	Azospirillum brasilense	No effect on growth or Nitrogen Fixation
Simazine (H)*	Azotobacter chroococcum	No effect on growth, high concentration increased Nitrogen fixation
Methidathion (I)*	Azospirillum brasilense	Reduced nitrogen fixation
Diazinon (I)*	Azospirillum brasilense	No effect on growth or Nitrogen Fixation
Metsulfuron methyl (H)*	Pseudomonas sp.	Growth inhibition

Note (I)*: Insecticides, (H)*: Herbicides

It was found in the soil sample analysis in laboratory that soil microorganism *Azospirillum brasilense* have residues of Bromopropylate, *Azotobacter chroococcum* have some residues of Simazine, *Azospirillum brasilense* have residues of both Methidathion and Diazinon, and *Pseudomonas sp.* Have residues of Metsulfuron methyl. There was no effect of Bromopropylate on *Azospirillum brasilense* with regards to nitrogen fixation. It was found that Metsulfuron methyl on *Pseudomonas sp.* have growth inhibition effects (Table 1). The findings were supported by a group researcher that pesticides such as Simazine have residue of *Azotobacter chroococcum*; but does not have any effect on organism's growth and nitrogen concentration (Schjonning et al., 2003). From the study of it was clear that some *Azotobacter* species degrade aromatic components like insecticides or herbicides in the soil (Mousa et al., 2021; Castillo et al., 2020; Kahraman and Altin, 2020). Similarly, Metsulfuron methyl residing in *Pseudomonas sp.* noted with growth inhibition consequences.

3.2 Effect of temperature in the microbial activities

	10°C	15°C	20°C	25°C	30°C	35°C	40°C
Azospirillum brasilense	20%	30%	35%	43%	55%	70%	87%
Azotobacter chroococcum	10%	15%	30%	55%	75%	89%	94%
Azospirillum brasilense	15%	29%	34%	40%	67%	90%	95%
Pseudomonas sp.	25%	32%	40%	50%	78%	95%	98%

The study reflected the increase in temperature has an incremental effect in activities of micro-organism. The activities remained for 20, 10, 15 and 25% through the activities of *Azospirillum brasilense*, *Azotobacter chroococcum*, *Azospirillum brasilense* and *Pseudomonas sp.* respectively at 10°C. The rate of activities increased up to 87, 94, 95, and 98% at 40°C through the microorganism namely *Azospirillum brasilense*, *Azotobacter chroococcum*, *Azospirillum brasilense* and *Pseudomonas sp.* respectively (Table 2). The study was conducted with variable temperature with constant levels of pesticides in the soil structure.

The study was supported by numerous researchers namely (Nowak et al., 2020; Muskus et al., 2020; Helweg, 1993; Bouseba et al., 2009). This investigation was also supported by the study by most of researcher as well (Davidson and Janssens, 2006; Nuccio et al., 2020). The research conducted also revealed that environmental factors such as temperature have imperative effects in soil microorganisms and soil health (Bao et al., 2020). From the study it was clear that large pesticides have residual effects in soil microorganism while environmental factors have

detrimental effects in soil microorganism in Chitwan district of Nepal.

4. CONCLUSION

The contamination and threat of soil were determined by collecting variable soil samples. The study was carried in November 2022 to December 2022 in Chitwan district of Nepal. 10 soil samples were collected from different and alternative parts of the district. Soil samples were selected from farmers' fields and fallow lands. Laboratory study was carried out for each sample of soil collected to determine the effect of variable temperature and pesticides in different soil microorganisms. Soil microorganisms such as *Azospirillum brasilense*, *Azotobacter chroococcum* and *Pseudomonas sp.* found with pesticide residues of Methidathion, Simazine and Metsulfuron methyl with effect in nitrogen fixation and growth of respective microorganisms. The effect of higher temperature (40°C) was found with peak activity in *Azospirillum brasilense*, *Azotobacter chroococcum*, *Azospirillum brasilense*, and *Pseudomonas sp.* Study on other environmental factors in multi-soil parameters is suggested for further investigation.

CONFLICT OF INTEREST

Both the authors (Mr. Janak Pant and Mrs. Prava Dawadi) commit that the research is free of any type of conflict of interest.

FUNDING STATEMENT

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my supervisor, Asst. Prof. Suraj Karki for his insightful support, invaluable guidance & supervision. I thank the support Agriculture and forestry University, Chitwan, Nepal has provided while carrying laboratory analysis. I always remember the kind support I got from the staff of municipalities and farmers of Chitwan district. I think this entire work was impossible without the support of my family. I am indebted to my parents for all kinds of desired support. I am highly thankful to my teammates and colleagues who have consistently supported me during the research and article preparation process. Lastly, I must thank all known and unknown helping hands from my organization, and all others respected persons.

REFERENCES

- Abdel-Rahman, H.R. 1999. Influence of temperature, microbial activity and soil characteristics on the dissipation of carbofuran and pirimicarb in Egypt. In: Proceedings of the 2nd Int. Conf. of Pest Control. 6-8 Sept. 1999, Mansoura, Egypt. Pp. 521-531.
- Ahlgren, G., Lundstedt, L., Brett, M., Forsberg, C., 1990. Lipid composition and food quality of some freshwater phytoplankton for cladoceran zooplankters. *Journal of Phytoplankton Research*. 12, 809-818.
- Bao, T., Liu, S., Qin, Y., Liu, L.Z., 2020. 3D modeling of coupled soil heat and moisture transport beneath a surface fire. *Int. J. Heat Mass Transf.* 149, Pp. 119163.
- Bouseba, B., Zertal, A., Beguet, J., Rouard, N., Devers, M., Martin, C., Martin-Laurent, F., 2009. Evidence for 2,4-D mineralization in mediterranean soils. *Pest Management Science*. 65 (9), Pp. 1021-1029.
- Byrne, M.P., 2021. Amplified warming of extreme temperatures over tropical land. *Nat. Geosci.* 14, Pp. 837-841.
- Castillo, T., García, A., Padilla-Córdova, C., Díaz-Barrera, A., Peña, C., 2020. Respiration in *Azotobacter vinelandii* and its relationship with the synthesis of biopolymers. *Electron J Biotechnol.* 48, Pp. 36-45. <https://doi.org/10.1016/j.ejbt.2020.08.001>
- CBS. 2019. Environment Statistics of Nepal Central Bureau of Statistics, Kathmandu, Nepal. p. 239.
- Central Bureau of Statistics (CBS). 2003. National Sample Census of Agriculture, Nepal, 2001/02: highlights. Government of Nepal (Kathmandu): National Planning Commission and Central Bureau of Statistics.
- Chen, H., Zhu, T., Li, B., Fang, C., Nie, M., 2020. The thermal response of soil microbial methanogenesis decreases in magnitude with changing temperature. *Nat. Commun.* 11, Pp. 5733.
- Chenguang, G.S., Emilia, H.P.M., Van Bodegom, T., Martijn, B.F.T., 2004. Land use intensity differently affects soil microbial functional

- communities in arable fields. *Applied Soil Ecology*, 204, Pp. 105-723. <https://doi.org/10.1016/j.apsoil.2024.105723>.
- Davidson, E.A., Janssens, I.A., 2006. Temperature sensitivity of soil carbon decomposition and feedback to climate change. *Nature*, 440, Pp. 165-173.
- Ecobichon, D.J., 1991. Toxic effects of pesticides. In: Amdur MO, Doull J, Klassen CD, editors. *Casarett and Doull's toxicology*. 4th edition. New York: Pergamon Press. Pp. 2-18.
- FAO, 2020. State of Knowledge of Soil Biodiversity-Status, Challenges and Potentialities: Report. Rome, FAO.
- Gadd, G.M., 2007. Geomycology: biogeochemical transformations of rocks, minerals, metals, and radionuclides by fungi, bioweathering and bioremediation. *Mycological Research*, 111,(1), Pp. 3-49.
- Gougoulis, C., Clark, J.M., Shaw, L.J., 2014. The role of soil microbes in the global carbon cycle: Tracking the below-ground microbial processing of plant-derived carbon for manipulating carbon dynamics in agricultural systems. *Journal of the Science of Food and Agriculture*, 94, Pp. 2362-2371. doi: <https://doi.org/10.1002/jsfa.6577>.
- Helweg, A., 1993. Degradation and adsorption of 14C-mecoprop (MCP) in surface soils and in subsoil. Influence of temperature, moisture content, sterilization, and concentration on degradation. *Science of the Total Environment*, 132, Pp. 229-241.
- Kahraman, B., Altın, A., 2020. Evaluation of different approaches for respiratory quotient calculation and effects of nitrogen sources on respiratory quotient values of hydrocarbon bioremediation. *Water Air Soil Pollut.*, 231 (38), 1. <https://doi.org/10.1007/s11270-020-04763-z>
- Kalia, A., Gosal, S.K., 2011. Effect of pesticide application on soil microorganisms. *Archives of Agronomy and Soil Science*. 57, Pp. 569-596.
- Khan, N., Bano, A., Curá, J.A., 2020. Role of Beneficial Microorganisms and Salicylic Acid in Improving Rainfed Agriculture and Future Food Safety. *Microorganisms*, 8, Pp. 10-18.
- Krishna, M.P., Mohan, M., 2017. Litter decomposition in forest ecosystems: a review. *Energy, Ecology and Environment*, 2, Pp. 236-249.
- Mousa, N., Adham, A., Merzah, N., Jasim, S., 2021. *Azotobacter* spp. bioremediation chemosate. *Asian J Water Environ Pollut*. 18, Pp. 103-107. <https://doi.org/10.3233/ajw210034>
- Muskus, A.M., Krauss, M., Miltner, A., Hamer, U., Nowak, K.M., 2020. Degradation of glyphosate in a Colombian soil is influenced by temperature, total organic carbon content and pH. *Environmental Pollution*, 259, Pp. 113-767.
- Nowak, K.M., Miltner, A., Poll, C., Kandeler, E., Streck, T., Pagel, H., 2020. Plant litter enhances degradation of the herbicide MCPA and increases formation of biogenic non-extractable residues in soil. *Environment International*, 142, Pp. 105-867.
- Nuccio, E.E., 2020. Niche differentiation is spatially and temporally regulated in the rhizosphere. *ISME J*. 14, Pp. 999-1014.
- Ortiz, A., Sansinenea, E., 2021. Recent advancements for microorganisms and their natural compounds useful in agriculture. *Appl. Microbiol. Biotechnol.*, 105, Pp. 891-897.
- Philipp, M., Fabian, S., Lisa, E., Carolin, H., Zuzana, H., Jakub, H., Christian, P., Ellen, K., 2024. Effects of MCPA and difenoconazole on glyphosate degradation and soil microorganisms. *Environmental Pollution*, 362, Pp. 124-926. <https://doi.org/10.1016/j.envpol.2024.124926>
- Prakash, J., Mishra, S., 2022. Role of beneficial soil microbes in alleviating climatic stresses in plants. In *Microbiome Under Changing Climate*; Kumar, A., Singh, J., Romanholo-Ferreira, L.F., Eds.; Woodhead Publishing: Sawston, UK. Pp. 29-68.
- Russell, D.J., Naudts, E., Soudzilovskaia, N.A., Briones, M.J.I., Çakır, M., Conti, E., Cortet, J., Fiera, C., Hackenberger Kutuzovic, D., Hedde, M., Hohberg, K., Indjic, D., Krogh, P.H., Lehmitz, R., Lesch, S., Marjanovic, Z., Mulder, C., Mumladze, L., Murvanidze, Rick, S.M., Roß-Nickoll, M., Schlaghamerský, J., Schmidt, O., Shelef, M., Suhadolc, M., Tsiafouli, A., Winding, A., Zaytsev, A., 2024. Advanced international data warehouse for collating and using soil biodiversity datasets. *Applied Soil Ecology*, 204, Pp. 105-710. <https://doi.org/10.1016/j.apsoil.2024.105710>
- Schjønnig, P.S., Elmholt, B.T., Christensen, M., 2003. Technology & Engineering. Non-target effects of pesticides on soil microorganisms. <https://books.google.com.np/books?isbn=085199850X>
- Uroz, S., Calvaruso, C., Turpault, M.P., Frey-Klett, P., 2009. Mineral weathering by bacteria: ecology, actors, and mechanisms. *Trends in Microbiology*. 17, 378-387
- Vitousek, P.M., Cassman, K., Cleveland, C., Crews, T., Field, C.B., Grimm, N.B., Howarth, R.W., Marino, R., Martinelli, L., Rastetter, E.B., Sprent, J.I., 2002. Towards an ecological understanding of biological nitrogen fixation. *Biogeochemistry*, 57, Pp. 1-45.

