International Journal of Research Publication and Reviews, Vol 6, Issue 6, pp 11315-11320 June 2025

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Physicochemical Assessment of Soil in Paraquat Applied Agricultural Fields in Buldhana District

Kokate V. S. [a]***, Patil Y.S.***[a]***, and Narkhedkar V. R.***[b]*****

[a] *Shri Dnyaneshwar Maskuji Burungale Science and Arts College, Shegaon, 444203, India*

[b] *Mahatma Jyotiba Fule Commerce, Science and Vitthalrao Raut Art's College, Bhatkuli, 444602, India*

A B S T R A C T

Man's survival depends on sustainable agriculture, particularly in light of our fast-growing population. It is not desirable for agriculture to spread into the remaining natural vegetation regions because this would decrease the planet's biodiversity. To enhance the crop productivity, weedicides/herbicides are being preferred at very large scale. The herbicide paraquat is widely used around the world to eradicate weeds from cultivated crop fields since it is both affordable and effective. These substances have detrimental impacts on the physicochemical characteristics of soil and remain in the soil for extended periods of time after application. In view of this, present investigation was undertaken to comparatively assess the effect of paraquat on agriculture field. The data revealed that paraquat application showed variable response on different parameters undertaken for the study.

Keywords: Paraquat, agriculture, physicochemical, pH.

1. INTRODUCTION

A variety of different species can find a home in the soil, which is a complex and dynamic biological system. Crop productivity, soil sustainability, and environmental quality are all greatly impacted by these organisms, which also perform vital biogeochemical cycles that preserve the health and equilibrium of soil ecosystems (Smith et al., 2015). One of the many anthropogenic stresses on the soils is the application of artificial pesticides to crops in an effort to reduce crop loss from weeds and pests (Wall et al., 2015).

One of the chemicals frequently present in arable soils is herbicide, which is used to eradicate undesirable vegetation. In order to guarantee high-quality and high-yield primary produce, they are purposefully released into the agroecosystem. These chemicals undergo testing to make sure their active ingredients don't have significantly detrimental ecotoxicological impacts on the environment before being put on the market (Regulation, 2009).

The greatest rates of pesticide usage per hectare during 2016–17 were seen in Punjab, Haryana, and Maharashtra, according to the studies (Subash et al., 2017). However, the biodiversity and functions of soil are seriously threatened by the use of herbicides in traditional agriculture (Van-Camp, 2004). These substances have detrimental effects on the microbial flora in the soil and remain in the soil for extended periods of time after application. In the photosynthetic membrane, Paraquat is a fast-acting, non-selective contact herbicide that is absorbed by the leaves and known to affect Photosystem 1. They are known to have inhibitory effects on microorganisms, which lowers mycelial growth and enzymatic activity (Stanley et al., 2013).

The present study aims to reveal the impact of applying paraquat herbicide on agricultural soil from three different locations in the Buldhana district.

2. MATERIALS AND METHODS

2.1 Sample Collection and Preparation

A reconnaissance survey was carried out in the Buldhana district, after which sites were selected for the assessment. Three different tehsil regions viz. Shegaon, Khamgaon and Buldhana were selected for soil sampling (Figure 1) during the period May 2023 to June 2023. At each tehsil region, two different locations were chosen. At each location, soil samples were collected from the agricultural field (AF) having history of paraquat herbicide application and the control field (CF) (without herbicide) from non-agricultural land in the vicinity area. The soil samples were prepared by thoroughly mixing, letting them dry at room temperature, and then filtering them through a 2 mm sieve. Photodegradation of weedicide was avoided by performing experiments in dark (Zhou et al., 2023).

* Corresponding author.
E-mail address: viveknarkhedkar@rediffmail.com

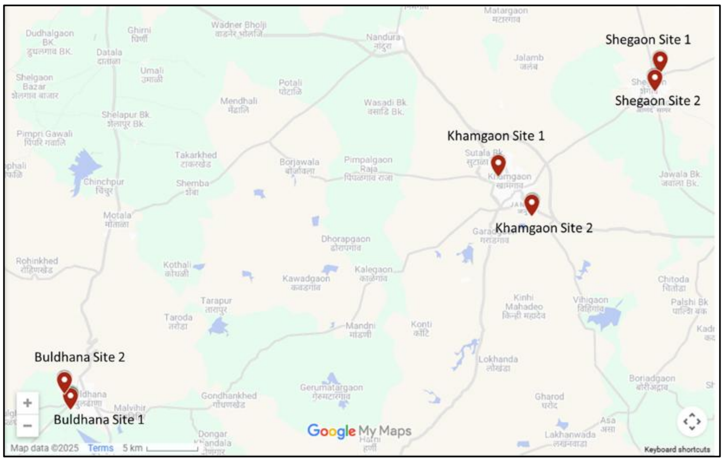

Figure 1 - Three tehsils in Buldhana district showing sampling locations

2.2 Physico-Chemical Analysis of Soil

All the collected soil samples were analyzed for its physico-chemical characteristics.

2.2.1 Soil texture

Bouyoucos (1962) hydrometer method was used to analyze the soil texture by particle size distribution, specifically the proportions of sand, silt, and clay. Here, the soil particles were dispersed in a liquid, and later the settling rates of the different particles was measured using a hydrometer.

2.2.2 pH

Soil pH determination was carried out using distilled water. Using distilled water, a 1:5 suspension was shaken for 30 minutes and then measured with a pH electrode.

2.2.3 Micronutrients

Micronutrients (Mn, Fe, Cu and Zn) were determined by colorimetric method using 0.1N HCl and read using Atomic Absorptive Spectrophotometer (AAS).

2.2.4 Organic Carbon

Organic carbon was determined by Walkley and Black (1934) wet oxidation method.

2.2.5 Moisture

Soil moisture was determined by Gravimetric method wherein a soil sample is weighed, dried in an oven, and re-weighed to determine the water content (Rasheed et al., 2022).

2.2.6 Water holding capacity (WHC)

Soil water holding capacity (WHC) was calculated by the MWHCFFPD method (Robertson et al. 1999 and Nelson et al., 2023). In this, a saturated soil sample was allowed to drain through a filter paper in a funnel, and the soil was weighed to measure the amount of water retained.

2.2.7 Electrical Conductivity

The Soil electrical conductivity (EC) was measured using a conductivity cell, typically in a 1:5 soil-water suspension (Fouad, 2023).

2.2.8 Cation Exchange Capacity

The Effective Cation Exchange Capacity (ECEC) was determined by using the values obtained for exchangeable bases from the soil analysis to calculate for the ECEC (Emamgholizadeh et al., 2023).

2.3 Data Analysis

The experiments were repeated three times and the results were statistically analyzed using GraphPad Prism version 7.0.

3. RESULTS AND DISCUSSION

The soils from agriculture fields (AF) and control fields (CF) from different locations of Buldhana district was analyzed for assessing the effects of paraquat herbicide on physicochemical properties.

The non-selective herbicide paraquat reacts with soil according to its texture. Because of electrostatic interactions, clay soils have a tendency to adsorb paraquat more strongly than sandy soils (Amondham, 2006, Gondar et al., 2012, and Huang et al., 2019). The soil samples collected in the study revealed silty loam and silty clay texture. Exceptionally, Buldhana site 2 showed the Loam texture of the soil (Figure 2). Soil texture plays a crucial role in how paraquat interacts with the soil environment. While adsorption to soil particles can limit its movement and bioavailability (Amondham et al., 2006 and Michael et al., 2024).

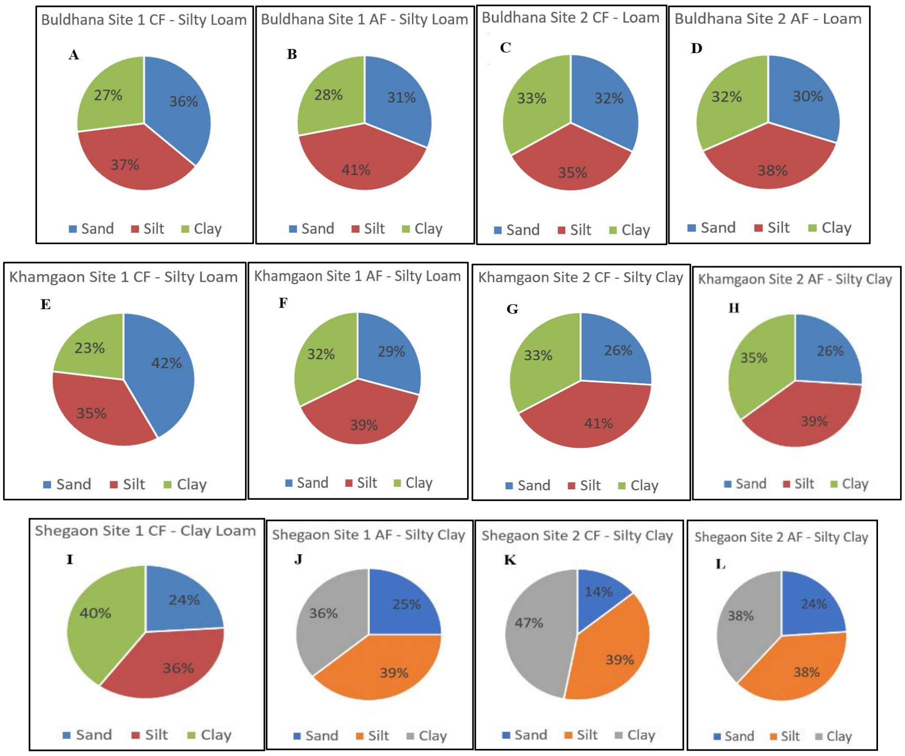

Figure 2 (A-L) - Variations in soil types collected from different sampling sites in Buldhana district

The AF soil samples showed the higher pH value as compared to the CF samples in its vicinity except for the Buldhana site 2 and Shegaon site 2. This indicates the shift from more acidic pH to the less acidic pH values in paraquat applied field. The maximum difference was noted in Khamgaon site 2 where CF has pH 6.63±0.28 and AF showed pH 6.8±0.34 (Figure 3). The common pesticide paraquat has complicated interactions with soil microbes and other soil characteristics, and it can alter the pH of the soil. According to some research, paraquat may raise the pH of soil from extremely acidic to acidic (Nurulalia and Mubin, 2021), however other research suggests that the impact may not be substantial (Stanley et al., 2013).

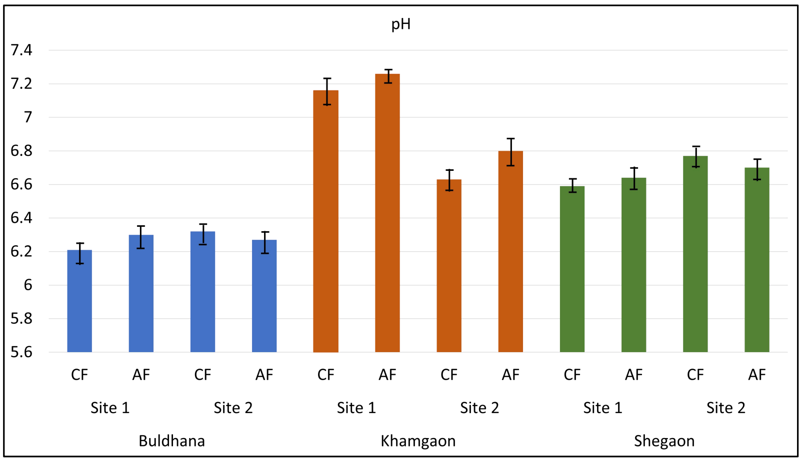

Figure 3 - Variations in pH level at different sampling sites in Buldhana district (mean±sd)

The maintenance of adequate concentration of micronutrients is essential component of the agricultural practices. The current study revealed that the except for the Khamgaon site 1, all AF samples showed the higher concentration of Zn than its respective CF samples. There, CF showed Zn 0.94±0.02 mg/Kg and AF showed 0.89±0.02 mg/Kg concentration (Table 1). Similarly, the lesser concentration of Cu in AF compared to its CF was noted in Buldhana site 1 and Shegaon 1. The maximum difference was 1.87±0.32 mg/Kg Cu in CF and 1.69±0.41 mg/Kg Cu in AF at Shegaon site 1 (Table 1). Similar is the case with concentration of Fe and Mn where AF showed higher concentrations of micronutrients as compared to its counterpart CF (Table 1). While paraquat may influence nitrogen cycling and soil arthropod populations, its effects on specific micronutrient concentrations are little understood (Dadang et al., 2019). Unlikely, more studies indicated that the application of paraquat can elevate soil levels of calcium, magnesium, and potassium, while potentially reducing salt concentrations (Nurulalia and Mubin, 2021).

Table 1 - Variations in micronutrient concentration in soils from different sampling sites in Buldhana district

Micronutrients (mg/kg)	**Buldhana**				**Khamgaon**				**Shegaon**			
	Site 1		**Site 2**		**Site 1**		**Site 2**		**Site 1**		**Site 2**	
	CF	**AF**	**CF**	**AF**	**CF**	**AF**	**CF**	**AF**	**CF**	**AF**	**CF**	**AF**
Zn	0.71±0.04	0.82±0.05	0.69±0.01	0.81±0.06	0.94±0.02	0.89±0.02	0.78±0.10	0.80±0.09	0.77±0.03	0.78±0.02	0.68±0.08	0.72±0.05
Cu	2.11±0.15	1.99±0.36	0.99±0.11	1.43±0.17	1.75±0.31	1.80±0.12	2.17±0.09	2.22±0.24	1.87±0.32	1.69±0.41	1.89±0.23	2.01±0.21
Fe	246.0±12.3	235.1±23.4	199.7±1.54	202.7±9.4	316.6±10.2	325.9±8.1	289.7±13.7	281.1±17.3	267.3±17.1	287.6±19.2	301.4±15.3	298.6±21.7
Mn	19.4±1.2	17.6±2.7	46.7±5.1	47.6±7.2	37.6±3.3	31.5±3.7	47.1±5.3	43.4±3.2	76.4±2.5	63.05±4.6	84.1±9.7	89.4±6.9

Table 2 - Variations in Organic carbon, moisture and WHC percentage in soils from different sampling sites in Buldhana district

%	**Buldhana**				**Khamgaon**				**Shegaon**			
	Site 1		**Site 2**		**Site 1**		**Site 2**		**Site 1**		**Site 2**	
	CF	**AF**	**CF**	**AF**	**CF**	**AF**	**CF**	**AF**	**CF**	**AF**	**CF**	**AF**
Org. Carbon	0.63±0.03	0.71±0.04	0.69±0.06	0.72±0.03	0.57±0.02	0.61±0.08	0.60±0.07	0.71±0.09	0.84±0.10	0.92±0.07	0.77±0.06	0.81±0.04
Moisture	47.6±2.4	51.7±2.9	39.4±2.7	42.8±4.1	51.8±3.2	53.9±2.6	37.9±7.1	42.7±3.3	29.3±2.6	33.5±3.7	43.2±1.9	52.8±3.1
WHC %	21.9±3.1	32.6±1.4	23.7±1.8	27.4±1.4	37.1±4.3	43.6±3.7	33.5±5.1	40.2±1.7	39.4±1.7	47.3±4.7	28.1±3.3	33.4±2.7

The decomposition of perished plant matter resulting from paraquat's herbicidal action may augment the organic carbon content in the soil (Gondar et al., 2012 and Chen et al., 2021). Likewise, all the studied sites indicate the higher percentage values of organic carbon in AF as compared to its CF. The highest difference was noted in Khamgaon site 2 i.e. CF organic carbon is 0.60±0.07% while AF showed 0.71±0.09% (Table 2). Similarly, moisture % and water holding capacity % follows the trend. In this also, paraquat applications in agricultural soil affects by increasing the moisture and water holding capacity of the soil (Table 2). The herbicidal action of paraquat may have an impact on vegetation cover and plant growth. Decreased vegetation may impact soil moisture content by increasing soil erosion and changing water infiltration and runoff patterns (Pan et al., 2013 and Paltseva, 2024).

Table 3 - Variations in Electric conductivity and Cation Exchange Capacity in soils from different sampling sites in Buldhana district

	Buldhana				**Khamgaon**				**Shegaon**			
	Site 1		**Site 2**		**Site 1**		**Site 2**		**Site 1**		**Site 2**	
	CF	**AF**	**CF**	**AF**	**CF**	**AF**	**CF**	**AF**	**CF**	**AF**	**CF**	**AF**
Electric Cond. (dS/m)	0.41±0.1	0.5±0.1	0.7±0.2	0.6±0.1	0.3±0.1	0.3±0.1	0.6±0.2	0.5±0.1	0.5±0.2	0.5±0.3	0.6±0.2	0.5±0.1
CEC (meq/100g)	14.7±1.4	17.1±2.2	13.9±2.3	14.8±1.6	16.5±2.0	15.6±1.7	36.3±2.4	37.1±4.7	35.1±2.3	41.8±2.6	39.4±1.3	39.6±2.1

The availability of nutrients and the general health of the soil are influenced by electrical conductivity and cation exchange capacity. Paraquat is known to be highly absorbed by soil, and the type of soil and application rate can affect how it affects CEC (Wapa et al., 2020). In the present assessment, electrical conductivity showed no significant difference in the values of AF and its CF samples. Although, the values are different, except for Khamgaon site 1, but the change in values is negligible. While in CEC of the AF and CF showed the considerable difference in the values. The maximum difference in CEC values was noted in Shegaon site I i.e. paraquat field 41.8±2.6 meq/100gm and control field 35.1±2.3 meq/100gm (Table 3).

4. CONCLUSION

The soil's physicochemical comparative assessment made between the paraquat applied agriculture field and the control vicinity field concludes that the paraquat application have significant effects on some parameters like organic carbon, moisture and water holding capacity. Moderate effects on pH, micronutrients and cation exchange capacity while insignificant or negligible effects on soil texture and electrical conductivity.

REFERENCES

Amondham, W., Parkpian, P., Polprasert, C., Delaune, R. D., & Jugsujinda, A. (2006). Paraquat adsorption, degradation, and remobilization in tropical soils of Thailand. Journal of Environmental Science and Health Part B, 41(5), 485-507.

Bouyoucos, G. J. (1962). Hydrometer method improved for making particle size analyses of soils 1. Agronomy Journal, 54(5), 464-465.

Chen, J., Su, Y., Lin, F., Iqbal, M., Mehmood, K., Zhang, H., & Shi, D. (2021). Effect of paraquat on cytotoxicity involved in oxidative stress and inflammatory reaction: A review of mechanisms and ecological implications. Ecotoxicology and Environmental Safety, 224, 112711.

Dadang, Hartono, A., Nurulali, L., & Soekarno, B. P. W. (2019). Effects of paraquat dichloride application on soil arthropods and soil chemical and physical properties in oil palm cultivation. J. ISSAAS 25(2), 174-184.

Emamgholizadeh, S., Bazoobandi, A., Mohammadi, B., Ghorbani, H., & Sadeghi, M. A. (2023). Prediction of soil cation exchange capacity using enhanced machine learning approaches in the southern region of the Caspian Sea. Ain Shams Engineering Journal, 14(2), 101876.

Fouad, M. (2023). Effect of peat, compost, and charcoal on transport of fipronil in clay loam soil and sandy clay loam soil. Current Chemistry Letters, 12(2), 281-288.

Gondar, D., López, R., Antelo, J., Fiol, S., & Arce, F. (2012). Adsorption of paraquat on soil organic matter: Effect of exchangeable cations and dissolved organic carbon. Journal of hazardous materials, 235, 218-223.

Gondar, D., López, R., Antelo, J., Fiol, S., & Arce, F. (2012). Adsorption of paraquat on soil organic matter: Effect of exchangeable cations and dissolved organic carbon. Journal of hazardous materials, 235, 218-223.

Huang, Y., Zhan, H., Bhatt, P., & Chen, S. (2019). Paraquat degradation from contaminated environments: current achievements and perspectives. Frontiers in Microbiology, 10, 1754.

Michael, Ikioukenigha, Esther Ejiro Abamba, Abdulmajeed Allan Chikukula, Dooshima Rita Dugeri, Ugochukwu Jones Ibeneme, Oluwaseyi Joseph Olukayode, Oghenerabome Okpro, and Augustine Akpome. (2024). Herbicides Effects on Soil Functions: A Review. Asian Soil Research Journal 8(4),34-41.

Nelson, J. T., Adjuik, T. A., Moore, E. B., VanLoocke, A. D., Ramirez Reyes, A., & McDaniel, M. D. (2024). A simple, affordable, do-it-yourself method for measuring soil maximum water holding capacity. Communications in Soil Science and Plant Analysis, 55(8), 1190-1204.

Nurulalia, L., & Mubin, N. (2021). Effect of paraquat dichloride application to the soil arthropods on the rice field, corn, and oil palm plantation. In IOP Conference Series: Earth and Environmental Science (Vol. 694, No. 1, p. 012045). IOP Publishing.

Paltseva, A. (2024). How Does Water Percolate Through Soils?. In The Urban Soil Guide: A Field and Lab Manual (pp. 53-57). Cham: Springer Nature Switzerland.

Pan, C., Zhao, H., Zhao, X., Han, H., Wang, Y., & Li, J. (2013). Biophysical properties as determinants for soil organic carbon and total nitrogen in grassland salinization. PloS one, 8(1), e54827.

Rasheed, M. W., Tang, J., Sarwar, A., Shah, S., Saddique, N., Khan, M. U., Imran Khan, M., Nawaz, S., Shamshiri, R. R., Aziz, M., & Sultan, M. (2022). Soil moisture measuring techniques and factors affecting the moisture dynamics: A comprehensive review. Sustainability, 14(18), 11538.

Regulation, E. (2009). No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC. EU, Brussels.

Robertson, G. P. (Ed.). (1999). Standard soil methods for long-term ecological research (Vol. 2). Oxford University Press.

Smith, P., Cotrufo, M. F., Rumpel, C., Paustian, K., Kuikman, P. J., Elliott, J. A., McDowell, R., Griffiths, R.I., Asakawa, S., Bustamante, M. and House, J.I. (2015). Biogeochemical cycles and biodiversity as key drivers of ecosystem services provided by soils. Soil, 1(2), 665-685.

Stanley, H. O., Maduike, E. M., & Okerentugba, P. O. (2013). Effect of herbicide (atrazine and paraquat) application on soil bacterial population. Sky Journal of Soil Science and Environmental Management, 2(9), 88-97.

Subash, S. P., Chand, P., Pavithra, S., Balaji, S. J., & Pal, S. (2017). Pesticide use in Indian agriculture: trends, market structure and policy issues.

Van-Camp, L. (Ed.). (2004). Reports of the technical working groups established under the thematic strategy for soil protection. Office for Official Publications of the European Communities.

Walkley, A., & Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil science, 37(1), 29-38.

Wall, D. H., Nielsen, U. N., & Six, J. (2015). Soil biodiversity and human health. Nature, 528(7580), 69-76.

Wapa, J. M., Iwok, I. T., & Aniah, A. I. (2020). Physical and chemical properties of soil influenced by Paraquat herbicide application in Gwagwalada area council, Abuja, Nigeria. Journal of Agripreneurship and Sustainable Development, 3(2), 36-43.

Zhou, P., Qin, B., Zhang, L., Wu, Z., Dai, Y., Hu, C., Xu, H. & Mao, Z. (2023). Facile construction of photocatalytic cellulose-based sponge with stable flotation properties as efficient and recyclable photocatalysts for sewage treatment. International Journal of Biological Macromolecules, 239, 124233