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Research Article

Effect of Wildfires on Mobility of Metribuzine Herbicide in Agricultural Soil

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ABSTRACT

Metribuzine has been used extensively to control weeds and grasses, which could cause severe groundwater and soil contamination. Wildfires are an important process in environment, which can be severe for many areas and could have an effect on soil properties. The purpose of this research was to evaluate the effect of wildfires for the fate and transport of atrazine for agricultural soil. Miscible-displacement experiments were used for the objectives. Results showed that the soil-water distribution coefficient (Kd) from metribuzine was 0.28 and 0.13 L/Kg for soils prior to and after wildfire, respectively. Results showed that organic matter fraction of soil has predominantly played role on sorption of metribuzine and exhibited rate-limited sorption-desorption. In addition, sorption of metribuzine onto soil after wildfire was significantly lower which likely causes more risk of contamination for groundwater resources.

1. INTRODUCTION

Wildfires are very important natural process for the environment and their increasing frequency and severity in effected areas could lead to change in ecosystems. After wildfire, loss of vegetation and changes to soil properties could cause flowing of water over the land surface during storms and delivery of debris and sediments to surface water. Wildfires could also cause predominant impact on the physical and chemical properties of the soil. Wildfire burns the vegetation and organic matter components in soil and that could increase soil density and reduce permeability and porosity.

Soil and groundwater contamination by pesticides tends to pose a risk to environment and human health. The negative effect of herbicide loading on environment and human health and their mobility in various soils has been under attention las few decades. Metribuzine is one of the most used herbicide to control weeds and grasses around agricultural part of countries. Sorption and desorption phenomenon plays an important role for mobilities of herbicides in soils that has predominant effect on groundwater and soil remediation efficacy [1]. Soil paramaters such as pH, clay content, organic carbon content and Cationic Exchange Capacity (CEC) have been studied to have impact on mobilities of herbicides [1, 2, 3]. Some studies revealed that sorption of triazines were dependent on most likely organic matter fraction in the soil [1, 2]. Other study showed that organic carbon fraction in carbonate soil was mainly responsible for triazine group herbicide [3]. The impact of organic carbon for the sorption behavior of pesticide has also been observed for other study [4].

In July and August 2021, a serious wildfires burnt 1,700 square kilometres of forest in Turkey's Mediterranean Region. The wildfires started in Manavgat, Antalya Province, on 28 July 2021. Wildfire predominantly had severe effect on vegetation and soil in the area. The objective of this study was to evaluate the impact of wildfires on mobilities of metribuzine herbicide for agricultural soil from Manavgat, Antalya.

2. MATERIALS and METHODS

Soils were obtained from locations from Manavgat Antalya from Turkey. Second soil was taken from the wildfire area to compare the effect of wildfire on herbicide mobility. Soil samples were sieved through 2-mm mesh screen. Chemical and physical features of soils are reported in Table 1. The pH of was analyzed by pH electrode. A particle-size determination of soil was conducted using hydrometer which was given in other study [4]. Total organic carbon of the soil was evaluated by Walkey–Black method [5].

Tablo 1. Physical and chemical properties of soils prior to and after wildfire

Physical and Chemical Properties	Soil 1	Soil 2*
Sand (%)	72	64
Silt (%)	24	31
Clay (%)	4	5
Texture	Sandy Loam	Sandy Loam
Bulk Density, ρ_b(g/cm^3)	1.59	1.63
Porosity	0.48	0.42
$pH_{(1:1)}$	7.8	7.6
Total Organic Carbon, TOC (%)	1.01	0.78

Analytical-grade metribuzine was made in 0.02 M $CaCl_2$. Pentafluorobenzoic acid (PFBA) (Aldrich Chemical Co., Inc.) was used as a non-reactive tracer to identify the hydrodynamic flow behavior in selected soil. The columns were made of plexiglass materials with PTFE caps (10-cm long by 2-cm diameter). Miscible-displacement experiments were performed at two porous media and two different initial metribuzine herbicide concentrations (Co = 20 and 100 mg/L) under saturated flow conditions (Table 2). The columns were fully filled with soil and saturated with water before conducting metribuzine miscible-displacement experiments. Non-reactive tracer PFBA tests were conducted to evaluate flow conditions in selected soils prior to metribuzine flooding. After reaching water saturation condition, PFBA or metribuzine solution was injected into the column until effluent concentration reached initial effluent concentration. After PFBA or metribuzine flooding, water was injected to column to get tracer out of the column. During the miscible-displacement experiments, samples were obtained from the column and analyzed. PFBA and herbicide breakthrough curves were made by drawing relative concentration (C/Co) versus Pore volume

(PV). PFBA and metribuzine were analyzed by UV–Visible spectrophotometer. Measured wavelengths are 254 nm and 233 nm for PFBA and metribuzine, respectively. BTCs of metribuzine and PFBA were analyzed using moment analysis to calculate the retardation factor and mass recoveries for PFBA and metribuzine.

Tablo 2. Experimental conditions for miscible displacement experiments

Solutions	v (cm/hr)	R [ ]	Column K_d (L/kg)	Mass Recovery (%)
PFBA	26.0	1.0	0	101.1
20 mg/L Metribuz.	26.0	1.94	0.28	97.4
100 mg/L Metribuz.	26.0	1.91	0.27	98.6
*20 mg/L Metribuz.	26.0	1.48	0.14	99.3
*100 mg/L Metribuz.	26.0	1.46	0.13	99.2

3. RESULTS

Miscible displacement experiments were performed for two various porous media and different metribuzine concentrations (Co=20 and 100 mg/L). Soil samples were represented as prior and after wildfire cases. Experimental conditions and results are given in Table 2. The BTCs for the conservative PFBA exhibit significantly symmetrical for both arrival/elution parts of breakthrough curves. This indicated the absence of retardation (R=1) which was also identified by moment analysis and confirmed the presence of ideal transport conditions in the soil system (Figure 1).

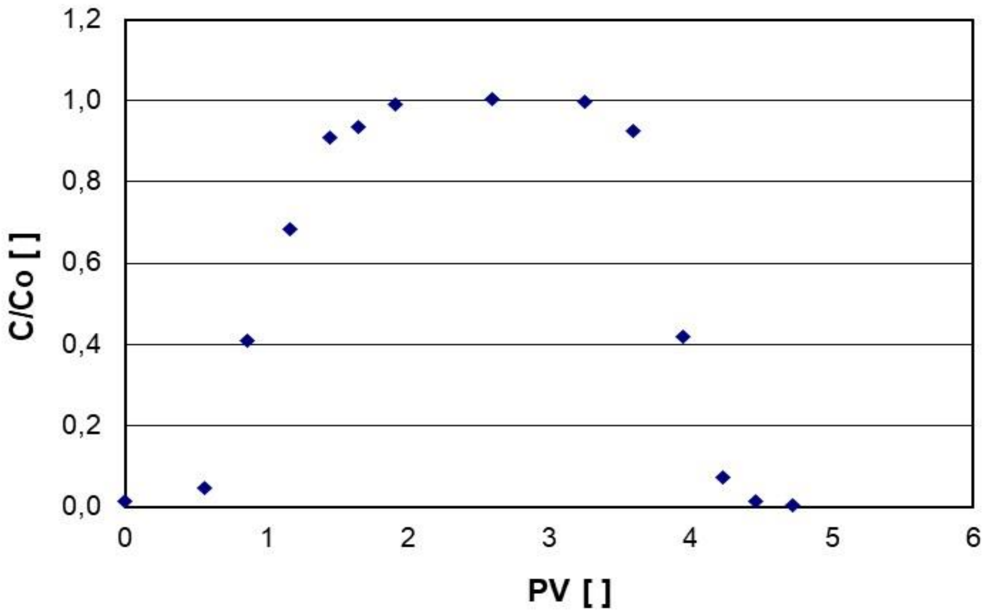

Figure 1. PFBA non-reactive tracer miscible displacement experiment breakthrough curves

Transport of metribuzine predominantly retarded relative to PFBA case in the soil (Fig. 2). K_d values and retardation factors (R) for metribuzine are reported in Table 2. According to the results, two different initial herbicide concentrations had negligible results in terms of retardation factor. This indicated the presence of linear sorption behavior for two different porous media condition (Table 2).

Miscible-displacement studies showed that sorption of metribuzine exhibited linear and rate-limited sorption and desorption parameters that predominantly contributed to the non-ideality for soil. This was identified due to the presence of organic carbon component in soil. The high mass recoveries (> 95%) postulated that transformation or irreversible effect of sorption did not influence the transport of metribuzine in soils. PFBA and metribuzine BTCs for 2 different soil condition and initial metribuzine concentration were reported in Fig 1 and 2. It was also postulated that following wildfire, percent of organic carbon fraction was reduced by 20%, which significantly led to the enhancement of metribuzine mobility in soil. Results indicated that retardation factor and K_d values were similar with other studies conducted in the Region of Mediterranen in Turkey [1, 2, 3, 4]. Organic carbon fraction is directly proportional to retardation fraction and K_d values which was identified by other studies [1, 2, 3, 4, 8, 10].

Metribuzine exhibited non-ideal transport behavior even for conditions prior to and after wildfire. This was due to the presence of organic components for both soils. The effect of organic fraction phenomenon was also observed by other researches that triazine sorption onto carbonate, iron oxide/hydroxide and clay mineral in porous media is negligible and the effect of organic fraction (> 0.1%) was predominant [1, 2, 3, 6]. This effect on non ideal sorption and desorption behavior for organic substances has been extensively studied in previous studies [1, 2, 3, 7, 8, 9, 10].

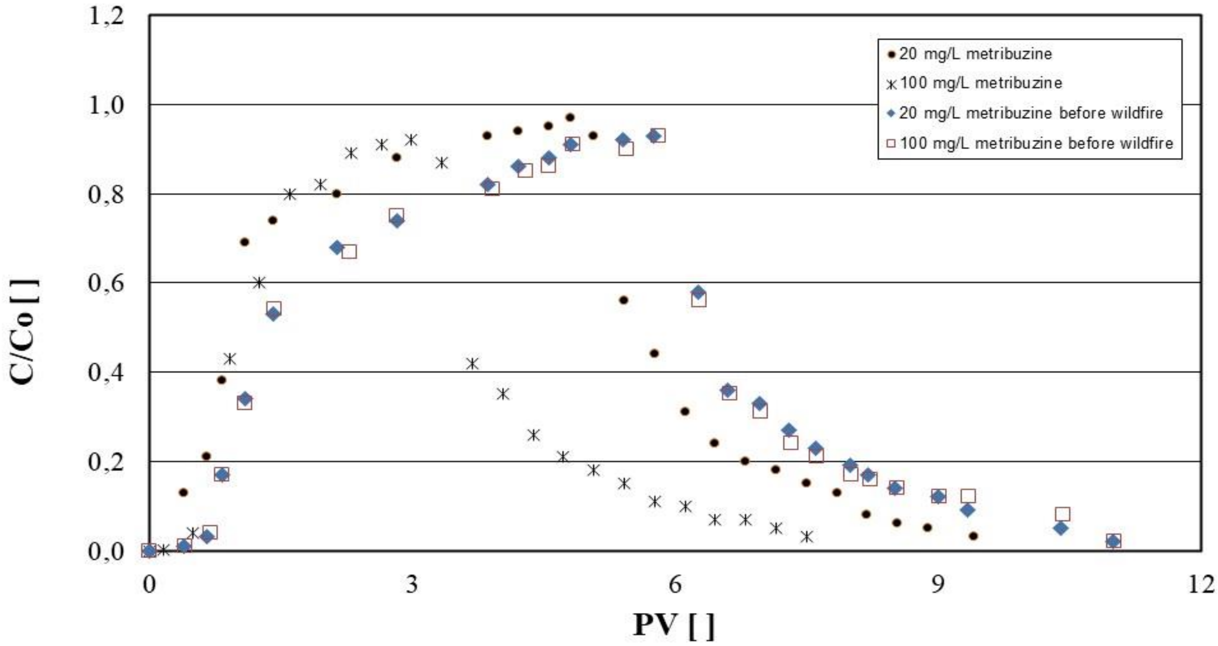

Figure 2. Metribuzine breakthrough curves for soils prior to and after wildfire

4. CONCLUSION

Wildfires are a natural process in many ecosystems, but they are increasing in size, severity, and frequency in many areas. Following the wildfire, loss of vegetation and environment could lead to have differences for the soil properties. Wildfires have a predominant effect on the physical and chemical properties of the soil. Metribuzine has been one of the most used triazine group herbicide which could cause extensive groundwater and soil contamination. The objective of this study was to investigate the effect of wildfires for the fate and transport of atrazine for agricultural soil. Miscible displacement experiments were used for the objectives. Miscible-displacement experiments were conducted for the objectives using 2 different agricultural soils. The calculated distribution coefficient (Kd) from linear sorption isotherm of atrazine was 0.28 and 0.13 L/Kg for soils prior to and after wildfire, respectively. Results indicated that that organic matter fraction of soil has predominantly played major role on sorption of metribuzine and exhibited rate-limited sorption-desorption. As a result, sorption of metribuzine onto soil after wildfire was lower which could lead to more risk for the contamination risk of groundwater resources. The results of this research would also help for the implementation of herbicide management strategies for contaminated sites.

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The Declaration of Conflict of Interest/ Common Interest

No conflict of interest or common interest has been declared by the author.

The Declaration of Ethics Committee Approval

This study does not require ethics committee permission or any special permission.

The Declaration of Research and Publication Ethics

The author of the paper declare that she complies with the scientific, ethical and quotation rules of ETOXEC in all processes of the paper and that she does not make any falsification on the data collected.

REFERENCES

[1] N.H Akyol, I Ozbay, B Ozbay, Effect of Organic Carbon Fraction on Long-Term Atrazine Elution Tailing for Two Heterogeneous Porous Media: Experimental and Modeling Approach.Water Air Soil Pollut.,226, 368, 2015.

[2] N.H Akyol, Characterizing and modeling of extensive atrazine elution tailing for stable manure amended soil. Chemosphere, 119, 1027-1032. 2015.

[3] B., Ozbay, N.H Akyol, G Akyol, İ Özbay, Sorption and desorption behaviours of 2,4-D and glyphosate in calcareous soil from Antalya, Turkey. Water and Environment Journal, 32, 141-148. 2018.

[4] N Koleli, C Kantar, U Cuvalci. H Yılmaz., Movement and adsorption of methamidophos in clay loam and sandy loam soil. Int. J. Environ. Anal. Chem., 86, pp. 1127-1134, 2006.

[5] L.E Allison, Organic carbon. In: Black, C.A. (Ed.), Methods of Analysis, Part 2, Chemical and Microbiological Properties # 9. American Society of Agronomy, Madison, WI, pp. 1367–1378. 1965.

[6] L Clausen, I., Fabricius, L Madsen, Adsorption of pesticides onto quartz, calcite, kaolinite and alpha-alumina. Journal of Environmental Quality, 30(3), 846–857. 2001.

[7] N.H Akyol, I Yolcubal, D Imer, Sorption and transport of trichloroethylene in caliche soil. Chemosphere, 82, 809-1816, 2011.

[8] A Kempf, M.L Brusseau, Impact of non-ideal sorption on low-concentration tailing behavior for transport in two natural porous media. Chemosphere, 77, 877-882, 2009.

[9] A Russo, G.R Johnson, G Schnaar, M.L., Brusseau, Non-ideal transport of contaminants in heterogeneous porous media: 8. Characterizing and modeling asymptotic contaminant-elution tailing for several soils and aquifer sediments. Chemosphere, 81, 366-371. 2010.

[10] N.H. Akyol, K.C. Carroll, E.C. Cortuk, Ö.C. Gündüz, N. Sahin, Comparison of sorption and solute transport behaviour of several herbicides in an alkaline agricultural soil. International Journal of Environmental Analytical Chemistry, 2023.