Integral Research (Peer-reviewed, Open Access & Indexed Multidisciplinary Journal) ISSN: 3048-5991
Journal home page: https://integralresearch.in/, Vol. 02, No. 01, January. 2025

Comparative Analysis of Forest Fire Effects on Soil Degradation in Hilly vs. Plain Terrains

Rajdeep Sood*
Research Scholar
Department of Zoology
PNG Govt. PG College
Ramnagar, Nainital, U.K.
&
Dr. Bhawna Pant
Assistant Professor
Department of Zoology
Government PG College
Dwarahat, Almora, U.K.

Abstract

Forest fires exert an influence on soil characteristics, nitrogen cycling and rate of deterioration so that the effects of forest fires are important ecological phenomena. This study investigates the effect of forest fires on topsoil properties of lowlands (Fatehpur Range) and hilly (Kosi Range) areas of Ramnagar forest division, Uttarakhand, India. The data collected and studied was of seasonal variation in soil pH, organic matter and nitrogen levels. The results show that topography affects fire effects and provides useful information to ensure sustainable management of forests.

Keywords: Forest fires, Soil degradation, Topsoil properties, Organic matter, Soil pH, Nitrogen levels.

Introduction

Forest fires, natural or man caused, have great ecological consequences. They can alter soil properties, nutrient dynamics, and vegetation patterns, contributing to soil erosion and degradation (Certini, 2005). A prime study area for the reasons of its high degree of diversification in its topography and also for its fire occurrences is the Ramnagar Forest Division (RFD) in Uttarakhand. The area covered by the division is spanned approximately by 487.36 km2, tropical deciduous forests being characterised by Sal (Shorea robusta) and Teak (Tectona grandis) (Champion & Seth, 1968). It is an important wildlife corridor for Chital deer

* Corresponding Author: Rajdeep Sood
Email: raj4rachna@gmail.com
Received 09 Jan. 2025; Accepted 20 Jan. 2025. Available online: 30 Jan. 2025.
Published by SAFE. (Society for Academic Facilitation and Extension)

(Axis axis), elephants (Elephas maximus), leopards (Panthera pardus), barking deer (Muntiacus muntjak) and sloth bears (Melursus ursinus). Forest fires in this region are extremely sensitive disturbance to ecological balance of the region. The purposes of this present study are to analyse the topographical aspects of two forest fire ranges, Kosi Range and Fatehpur Range, in order to estimate the impact of forest fires on the topsoil properties. The intention of the study is to learn these effects and to gain insights into sustainability of forest management and conservation strategies adaptable for habitat changes (Dave, 2008). The comparison made in this research is between the Fatehpur Range which is fairly flat and the predominantly hilly Kosi Range to understand how topography affects the effect of forest fires.

Review of Literature

It was shown that forest fires have considerable impact on the degradation of the soil in hilly and plain terrains by comparing their effects on the degradation of the soil in these two terrains. Overgrazing can also contribute to the reduction of nutrients in hilly areas after burning, due to the fact that they have steep slopes that enable the runoff of ash and soil particles (Certini, 2005). On the other hand, in feature these less erodible soils are plain terrains that experience less immediate erosion but a slower recovery of soil organic matter (DeBano, 2000). Studies have shown that hilly areas are often more alkaline after the fire because of the ash concentration containing basic cations that are mostly concentrated in the ash, whereas plains in general have more stable pH levels because of reduced ash dispersion (Bot & Benites, 2005). It stresses that post fire management has to be sensitive to how different terrain types are so vulnerable to such an event.

Study Area

The RFD extends over about 487.36 km² with tropical deciduous forest comprises of species like Sal (Shorea robusta) and Teak (Tectona grandis) (Champion & Seth, 1968). The Kosi Range submerges at an elevation of 630 meters displays a hilly terrain composed of high Chital population. On the other hand, the Fatehpur range, at 753 metres height, is of relatively flat terrain with high degree of human interaction (Forest Department Uttarakhand, 2019).

Methodology

Site Selection

Four fire exposed topographic conditions selected for sampling which were distributed across the two ranges. For forest fires, sampling locations were placed about 3 kilometers to 5 kilometers apart and strategically distributed to cover variations in properties of soil. The sites' coordinates were recorded, and fire histories were documented through field surveys and local consultations (Borchers & Perry, 1990).

Sample Design and Collection

Topsoil samples were collected from a depth of 0-15 cm. Vegetation quadrats (10 × 10 meters) were used to mark sampling areas. Litter was cleared before sample collection to avoid contamination. Samples were labeled and transported in sealed plastic bags to maintain integrity (Bouyoucos, 1951).

Laboratory Analysis

Soil pH was measured using a digital pH meter (Model MK VI), calibrated with standard buffer solutions (Boyer & Miller, 1994). Organic carbon was analyzed using the Walkley-Black method, while nitrogen content was determined using the alkaline permanganate method (Subbiah & Asija, 1956).

Results and Discussion

The fire season caused a significant increase in soil pH in both ranges, followed by a gradual return to pre-fire levels during the rainy season. Organic matter and total nitrogen levels showed a sharp decline during the fire season, reflecting the loss of nutrients due to combustion, but both recovered notably during the rainy season. These variations highlight the impact of forest fires on soil health and nutrient dynamics across different terrains.

Table 1. summarizes the seasonal variations in soil properties, including pH, organic matter (OM), and total nitrogen (TN), for the Kosi and Fatehpur ranges.

Season	Kosi pH	Fatehpur pH	Kosi OM (%)	Fatehpur OM (%)	Kosi TN (%)	Fatehpur TN (%)
Pre-fire	7.17	6.77	2.99	3.00	0.71	0.73
Fire	8.55	8.52	1.14	1.10	0.25	0.22
Summer	7.90	7.85	1.08	1.30	0.22	0.21
Rainy	6.91	6.86	3.07	2.95	0.84	0.76

Soil pH

Forest fires increased soil pH significantly in the topsoil. In the Kosi Range, pH rose from 7.17 (pre-fire) to 8.55 (fire season) before stabilizing during the rainy season. Similar trends were observed in the Fatehpur Range, where pH increased from 6.77 to 8.52 (Certini, 2005). This alkalinity results from the release of basic cations (e.g., Ca2+, Mg2+) during combustion.

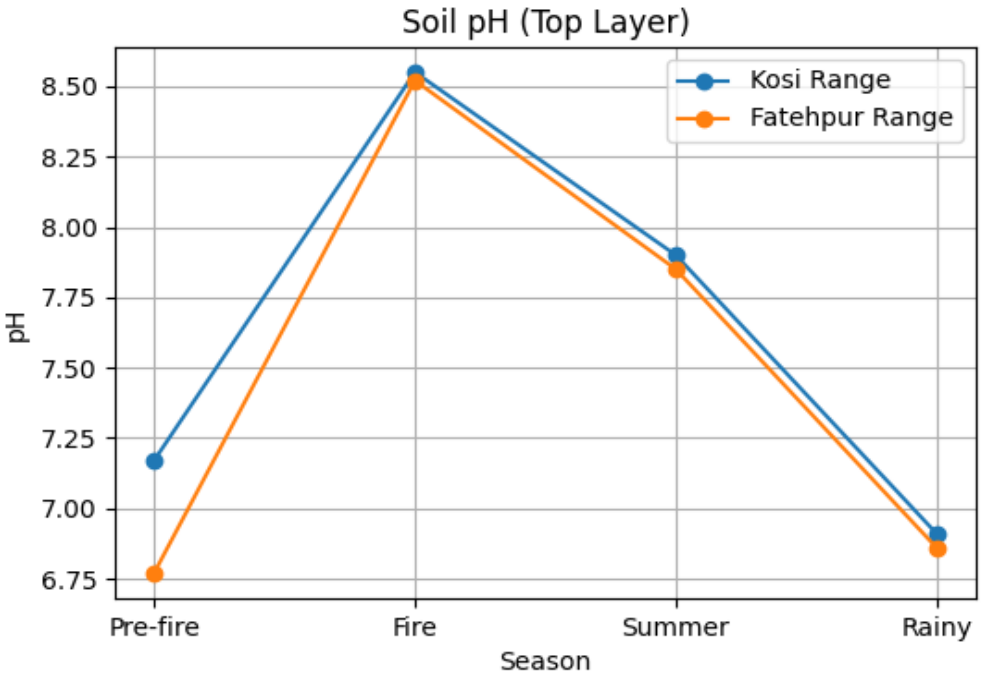

Figure 1: Seasonal Variations in Soil pH

Organic Matter (OM)

Fire reduced organic matter in the topsoil of both ranges, with the lowest levels recorded during the summer. In the Kosi Range, OM dropped from 2.99% (pre-fire) to 1.14% (fire season) but rebounded to 3.07% in the rainy season. Similar patterns were observed in the Fatehpur Range, reflecting the restorative role of precipitation (Bot & Benites, 2005).

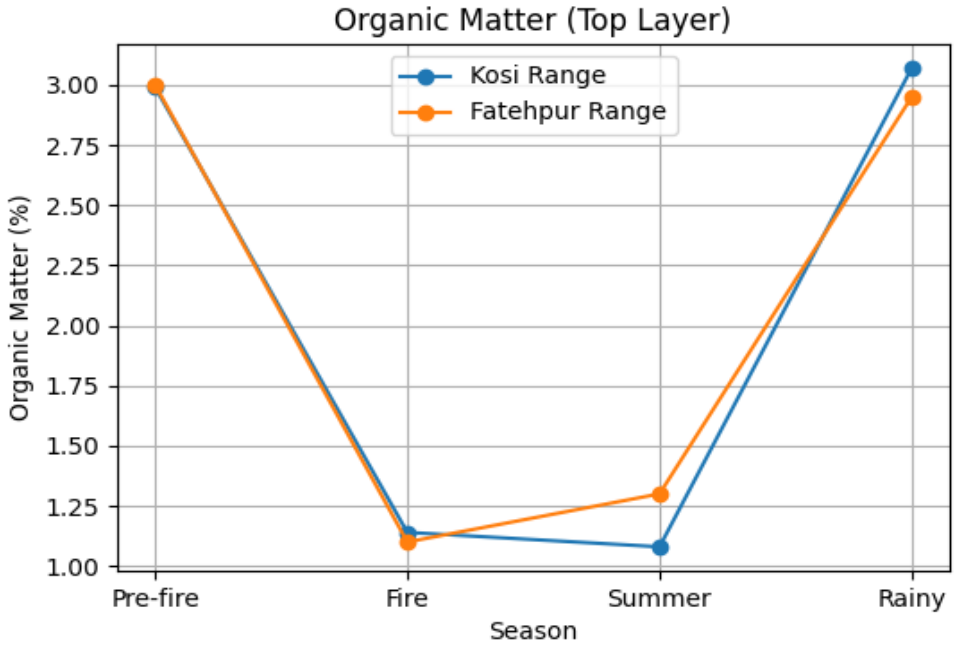

Figure 2: Seasonal Variations in Organic Matter

Total Nitrogen (TN)

Nitrogen content in the topsoil declined sharply during the fire season due to volatilization but recovered during the rainy season. The Kosi Range showed a TN reduction from 0.71% (pre-fire) to 0.25% (fire season), followed by an increase to 0.84% (rainy season). Similar trends were noted in the Fatehpur Range (DeBano et al., 1998).

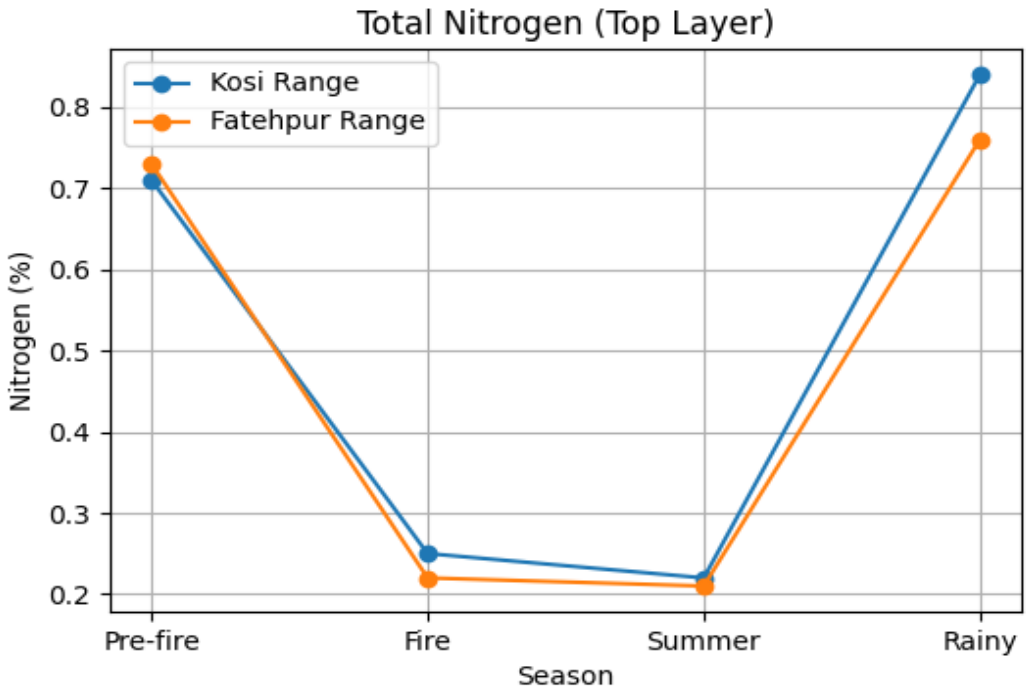

Figure 3: Seasonal Variations in Total Nitrogen

Conclusion

This study demonstrates that forest fires significantly impact topsoil properties, with topography playing a critical role in modulating these effects. Hilly terrains like the Kosi Range exhibit more pronounced nutrient losses compared to plains like the Fatehpur Range. These findings emphasize the need for tailored fire management strategies, including reforestation and soil conservation measures, to mitigate fire-induced degradation.

References:

Bot, A., & Benites, J. (2005). The importance of soil organic matter: Key to drought-resistant soil and sustained food production. Food and Agriculture Organization.

Bouyoucos, G. J. (1951). A recalibration of the hydrometer method for making mechanical analysis of soils. *Agronomy Journal, 43*(9), 434-438.

Certini, G. (2005). Effects of fire on properties of forest soils: A review. *Oecologia, 143*(1), 1-10.

Champion, H. G., & Seth, S. K. (1968). A revised survey of the forest types of India. Govt. of India Press.

Dave, C. V. (2008). Ecology of Chital (Axis axis) in Gir. Doctoral dissertation, Saurashtra University.

DeBano, L. F., Neary, D. G., & Folliott, P. F. (1998). Fire's effects on ecosystems. John Wiley & Sons.

Forest Department Uttarakhand. (2019). Forest division map of western circle, Uttarakhand. Retrieved from http://www.forest.uk.gov.in

Subbiah, B. V., & Asija, G. L. (1956). A rapid procedure for determination of available nitrogen in soils. *Current Science, 25*(8), 259-260.