# Changes in Physical and Chemical Soil Properties on Burnt Shrub Areas in Mediterranean Mountains, Northern Portugal

**F. Fonseca[1*], T. de Figueiredo[1], M. Leite[2]**

[1]Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança (ESAB/IPB), Apartado 1172, 5301-855 Bragança, Portugal, e-mail: *ffonseca@ipb.pt
[2]Escola Superior Agrária, Instituto Politécnico de Bragança, Apartado 1172, 5301-855 Bragança, Portugal

## Introduction

Human induced fire in scrublands to obtain better pastures for cattle is a relatively common practice in North Portugal. During burning, plant cover and litter layers are consumed, and the mineral soil is heated, resulting in changes to physical, chemical, mineralogical, and biological soil properties.
The extent and duration of the fire effects on soil properties depend on fire behaviour, especially related to fire severity, as well as on climatic conditions, mainly the characteristics of subsequent rainfall events.

## Materials and Methods

**Table 1. Sampling areas**

| Areas | Edroso | Revelhe |
|---|---|---|
| Location (Municipality) | Trás-os-Montes e Alto Douro , NE Portugal (Vinhais) | Entre Douro e Minho, NW Portugal (Fafe) |
| Lithology | Schist | Granite |
| Soils | Leptosols | Regosols |
| Vegetation | *Ulex europaeus* *Cytisus multiflorus* | *Ulex europaeus* *Cytisus multiflorus* |
| Temperature | 12,3ºC | 14,4ºC |
| Precipitation | 758 mm | 1466 mm |

- In burned and unburned areas, disturbed soil samples were collected at depths 0-5, 5-10, 10-15, 15-20 and 20-30cm (n = 8 in each case)
- Bulk density and permeability were determined in undisturbed samples, collected in 100 $cm^3$ cylinders (bulk density in the same depths above referred and permeability in the 0-5 cm layer)
- Burn severity was estimated qualitatively from post-fire fuel size diameter and degree of litter consumption

## Results and Discussion

Table 2. Soil bulk density (BD), total porosity (P) and permeability (Perm) . For each variable, different letters indicate significant differences between burned and unburned areas (*P<0.05*)

| Depth (cm) | Edroso BD (g $cm^{-3}$) | Edroso P (%) | Edroso Perm (cm $h^{-1}$) | Revelhe BD (g $cm^{-3}$) | Revelhe P (%) | Revelhe Perm (cm $h^{-1}$) |
|---|---|---|---|---|---|---|
| | | | Burned | | | |
| 0-5 | 1.30[a] | 51.1[a] | 47.1[a] | 1.29[a] | 64.2[a] | 12.2[a] |
| 5-10 | 1.30[a] | 50.8[a] | | 1.30[a] | 63.8[a] | |
| 10-15 | 1.41[a] | 46.8[a] | | 1.41[a] | 64.2[a] | |
| 15-20 | 1.35[a] | 49.0[a] | | 1.35[a] | 61.4[a] | |
| 20-30 | 1.42[a] | 46.6[a] | | 1.42[a] | 55.0[a] | |
| | | | Unburned | | | |
| 0-5 | 1.17[a] | 55.8[a] | 51.7[a] | 1.17[a] | 66.3[a] | 172.3[b] |
| 5-10 | 1.21[a] | 54.3[a] | | 1.21[a] | 65.8[a] | |
| 10-15 | 1.29[a] | 51.2[a] | | 1.28[a] | 63.8[a] | |
| 15-20 | 1.27[a] | 52.2[a] | | 1.26[a] | 66.2[a] | |
| 20-30 | 1.35[a] | 49.1[a] | | 1.35[a] | 62.3[a] | |

- After the fire, average bulk density showed a relative increase of 5% to 10% in the 20-30 cm and 0-5 cm soil layers, respectively.

A corresponding decrease was observed in the average values of porosity and permeability (Table 2).

- Burning leads to a decrease in sum exchange bases and increase in exchange aluminum (Table 3), with reflexes in soil pH values (Figure 1). Soils tend to acidify after fire.

Table 3. Exchangeable cations. For each variable, different letters indicate significant differences between burned and unburned areas (*P<0.05*)

| Depth (cm) | Edroso Ca | Edroso Mg | Edroso K | Edroso Na | Edroso Al | Revelhe Ca | Revelhe Mg | Revelhe K | Revelhe Na | Revelhe Al |
|---|---|---|---|---|---|---|---|---|---|---|
| | (cmol(+) $kg^{-1}$) | | | | | (cmol(+) $kg^{-1}$) | | | | |
| | | | | | Burned | | | | | |
| 0-5 | 1.81[a] | 0.92[a] | 0.55[a] | 0.64[a] | 2.30[a] | 1.41[a] | 0.51[a] | 0.27[a] | 0.23[a] | 2.24[a] |
| 5-10 | 1.30[a] | 0.74[a] | 0.45[a] | 0.61[a] | 2.10[a] | 1.31[a] | 0.52[a] | 0.31[a] | 0.28[a] | 2.50[b] |
| 10-15 | 1.20[a] | 0.74[a] | 0.43[a] | 0.59[a] | 1.90[a] | 1.25[a] | 0.50[a] | 0.31[a] | 0.30[a] | 2.93[b] |
| 15-20 | 1.29[a] | 0.74[a] | 0.39[a] | 0.61[a] | 1.80[a] | 1.28[a] | 0.74[a] | 0.29[a] | 0.28[a] | 2.78[b] |
| 20-30 | 1.20[a] | 0.75[a] | 0.30[a] | 0.63[b] | 1.79[a] | 1.30[a] | 0.46[a] | 0.28[a] | 0.29[b] | 2.71[b] |
| | | | | | Unburned | | | | | |
| 0-5 | 2.21[a] | 1.05[a] | 0.56[b] | 0.75[a] | 1.75[a] | 2.18[a] | 0.72[a] | 0.56[b] | 0.41[a] | 2.16[a] |
| 5-10 | 1.34[a] | 0.79[a] | 0.30[b] | 0.69[a] | 1.81[a] | 2.10[a] | 0.65[a] | 0.48[b] | 0.44[a] | 1.76[a] |
| 10-15 | 1.29[a] | 0.76[a] | 0.23[b] | 0.69[a] | 1.80[a] | 1.73[a] | 0.58[a] | 0.45[b] | 0.38[a] | 1.91[a] |
| 15-20 | 1.16[a] | 0.68[a] | 0.19[b] | 0.69[a] | 1.66[a] | 1.88[a] | 0.68[a] | 0.41[b] | 0.39[a] | 1.66[a] |
| 20-30 | 1.24[a] | 0.76[a] | 0.17[a] | 0.71[a] | 1.70[a] | 2.04[a] | 0.62[a] | 0.17[b] | 0.38[a] | 1.44[a] |

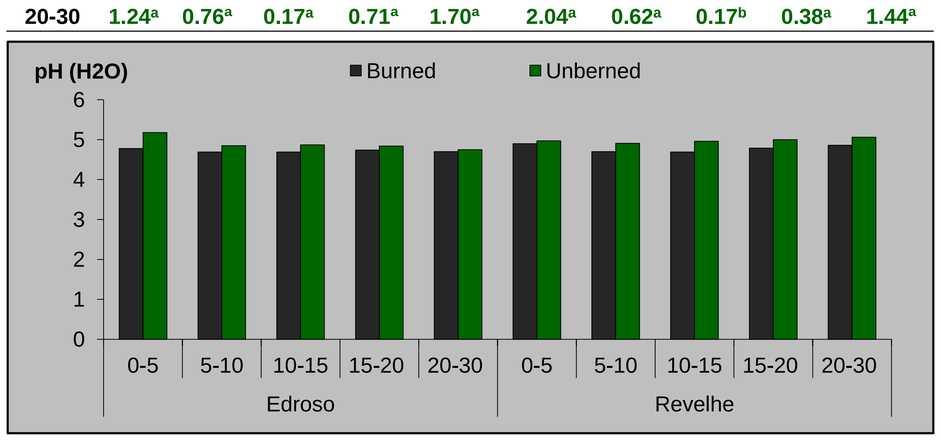


Figure 1. Soil pH ($H_2O$)

- After fire, an increase in SOM and in total N contents was found in most layers (Figure 2). In field observations huge quantities of charred materials were visibly deposited onto surface soil. After a moderate fire, an increase of SOM is usually observed, suggesting a substantial inclusion of charred plant materials and the presence of residual ashes. N-fixer soil microbial species are common new comers in burnt areas, and this may explain the high increase of total N in the upper layer (0-5 cm).

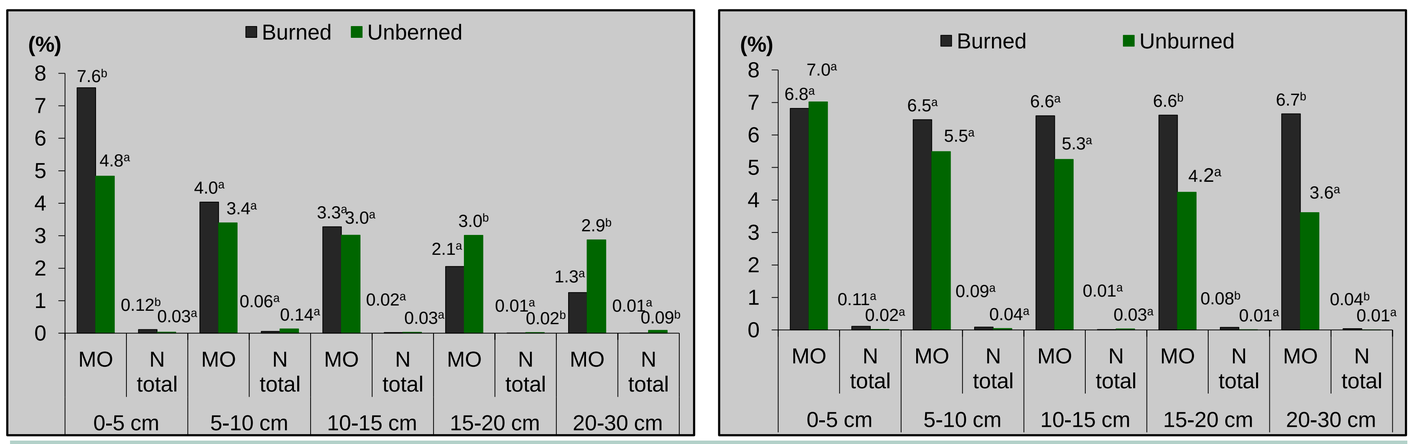


Figure 2. Soil organic matter and total nitrogen in both sampling areas: Edroso (left), Revelhe (right).

Table 4. Extractable P and K. For each variable, different letters indicate significant differences between burned and unburned areas (*P<0.05*)

| Depth (cm) | Edroso P | Edroso K | Revelhe P | Revelhe K |
|---|---|---|---|---|
| | mg $kg^{-1}$ | | mg $kg^{-1}$ | |
| | | Burned | | |
| 0-5 | 14[a] | 147[a] | 49[a] | 135[a] |
| 5-10 | 9[a] | 119[a] | 26[a] | 102[a] |
| 10-15 | 8[a] | 113[a] | 18[a] | 93[a] |
| 15-20 | 11[a] | 103[a] | 21[a] | 98[a] |
| 20-30 | 8[a] | 83[a] | 18[a] | 85[a] |
| | | Unburned | | |
| 0-5 | 34[b] | 165[a] | 44[a] | 141[a] |
| 5-10 | 21[b] | 106[a] | 41[a] | 119[a] |
| 10-15 | 23[b] | 93[a] | 39[a] | 116[a] |
| 15-20 | 16[a] | 88[a] | 40[a] | 92[a] |
| 20-30 | 12[a] | 85[a] | 46[b] | 87[a] |

- Phosphorus extractable decreased after the fire, while potassium maintains similar values before and after fire. These and other nutrients are generally deposited on the soil in ash, where they are susceptible to loss by erosion and leaching.

## Conclusion

The climatic conditions after fire (with high precipitation amounts, eventually leading high leaching rates and surface erosion) and low fire intensities (indicated by the presence of incompletely burnt materials), and consequently lower ash deposition, may partly explain the changes in soil properties found among burned and unburned shrublands.

European Geosciences Union, General Assembly 2014. Vienna, Austria, 27 April – 02 May 2014