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# Study Of The Physical, Chemical And Biological Properties Of Soils With Vertical Characteristics By Effects Of Burning Temperature In The Municipality Of Sincelejo, Department Of Sucre-Colombia

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**Abstract:** In the present investigation, some physical, chemical and biological (nematofauna) characteristics of a vertisol-type soil and the changes that occurred due to the effects of burning were evaluated. A statistical analysis of completely randomized blocks was carried out, where four experimental zones were used in shape of a box (4 m2) each, two samples were handled without burning and with burning at depths of (0 - 7.5) and (7 .5 - 15) cm, with three sampling and data collection treatments: (i) one hour before burning, (ii) immediately after and (iii) 30 days after burning. According to what was observed, there were alterations in some properties of the soil, which affect its fertility, leading to an accelerated degradation or desertification of these agro-ecosystems, thus generating a negative environmental impact. It is necessary to establish indicators of good management of soil, water, crops and environment resources, applying more friendly practices in their productive situations, in order to improve the agro-ecological conditions of the area.

**Keywords:** vertic floor; burning temperature; physical properties; Chemical properties; Biological properties

## 1. INTRODUCTION

Fire introduces negative or positive effects on the chemical and biological characteristics of soils. The incidence of fire in the soil modifies the physical-chemical and biological properties, which are a function of the state of the soil and its intensity and duration. When a repetition of fires takes place, the structure of the soil is degraded, increasing erodibility and decreasing fertility, leading the soil to a level of significant nutritional poverty (Cuesta, JR and Giraldo, IO (2013).

Due to the lack of knowledge of good agricultural and agro-ecological practices in general and of soil biology, small producers and peasants in the region are accustomed to traditional agricultural practices, where they employ cut, cover grave and burning, before establishing a crop, without taking precautions to the damage they generate to the soil and the environment where the food crop will be established, this practice of burning generates alterations in some physical, chemical properties and biological conditions of the soil, affecting its quality, thus leading to an accelerated degradation or desertification of these agro-ecosystems. Burning is one of the main sources of environmental pollution that exists worldwide. The felling and burning of vegetation constitutes a method of cultivation used for thousands of years for its effectiveness in clearing the land and making it suitable for quickly sowing crops that will produce food of immediate need. (Gomez, 2007). This, together with the initial high fertility of the soil immediately after burning, has allowed many people, generation after generation, to produce the food their families need. The technique is very common in shifting cultivation systems, which involves the felling of a new area each time a production cycle ends (Gómez, 2007).

Despite the immediate benefits that the slash-and-burn practice can initially generate, over time, it causes damaging and irreversible effects on the soil (Gómez, 2007). The physical properties of the soil undergo some considerable changes, especially in the upper layer. The increase in temperature during burning can lead to nutrient losses in the first layers of the soil (González, 1987). On the other hand, the pH of the soil undergoes a slight and progressive increase, linked to the immediate availability of cations in the ash (Mils, 2007). According to Martínez Becerra, Ramos Rodríguez, Castillo Martínez, Bonilla Vichot and Sotolongo Sospedra (2004), the Cation Exchange Capacity (CEC) decreases when a burn occurs, due to the degradation of organic and inorganic colloids; in such a way that the total CEC will remain low for at least one year after the burning (Gómez, 2007). Martínez and Becerra (2007), define the phenomenon called "biotic response", referring to the rapid increase in microbial activity that takes place immediately after burning, because of the increase in pH and the supply of cations and phosphorus. This sudden increase in activity by microorganisms leads to a consequent increase in the availability of nutrients for a short time. However, as the organic matter has been reduced to ashes, over time, the populations of microorganisms and their activity are considerably reduced (Gómez, 2007). At the time of burning, many organisms that favor the decomposition of organic matter and the availability of nutrients for plants also die (Torres Vargas, Quiroz Guerra & Juscamaita Morales, 2004). The conservation and proper management of the soil increases production, support and improvement of the biological and physicochemical properties of the soil, so that farmers, ranchers, entities of the agricultural sector, educators and the community of the region become aware and raise awareness of their health, good agricultural practices and agroecological knowledge must be adopted to stop future soil degradation, preventing desertification and a great negative environmental impact.

Through this research, it is intended to identify the positive and negative aspects in the physical, chemical and biological properties of vertic soils, which are altered by means of high temperatures generated by the effects of burning carried out on agricultural soils, with which will seek to generate a greater perception regarding the production of crops, to finally try to identify alternatives that lead to soil protection and the recovery of ecosystems.

## 2. MATERIALS AND METHODS

A work site (Farm "El Futuro"), in a rural area with geographic coordinates: 9°20'41" North, 75°27'34" West; located at a distance of 8 kilometers to the right margin of the road that leads from the municipality of Sincelejo to the corregimiento of "El Cerrito de las Palmas". Vertisol-type soils predominate on this farm. Traditional agricultural practices are carried out in the study area, such as supporting crops of cassava (Manihot esculenta Crantz), yam (Dioscorea sp.), as well as other activities, such as fish farming. It should be noted that in the study site, the application of the burning is generally carried out between the months of December to March, and then a crop is applied (See Figure 1).

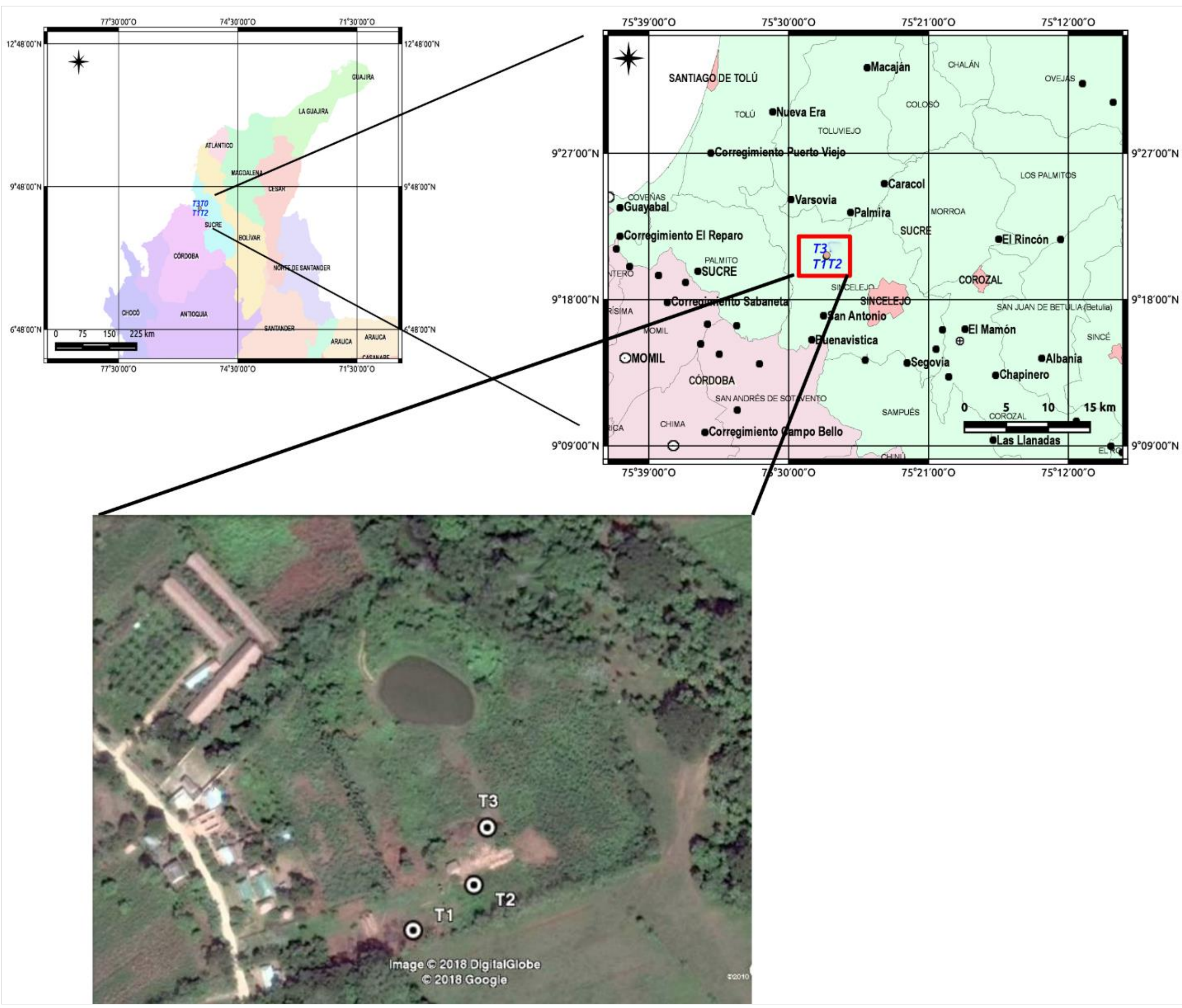

**Figure 1.** Location of the study site and its respective treatments.
Source: self made

## 2.1. Phase field

In order to evaluate the behavior of high temperatures in the soil and how this is reflected in the physical, chemical and biological properties, three sites were selected for experimental zones, which were carried out three different treatments (before burning, immediately after burning and 30 days after burning) and a control treatment. A pit was also made in the study area of approximately one meter deep.

## 2.2. Sampling

Were taken at two different depths: from 0.0 to 7.5 cm and from 7.5 to 15 cm, taking into account four treatments (three experimental treatments: "T1, T2 and T3" and one control, consisting of "a natural environment where no human activity is carried out") (Table 1). For the unaltered samples (physical and biological tests), these were stored in a refrigerator at 4°C for a maximum time of 7 days.

Some physical properties (natural moisture content, apparent density, real density and porosity), some chemical properties (pH, percentage of organic matter and cation exchange capacity "CEC") were determined in the Laboratory. In the case of biological properties, free-living edaphic nematodes were extracted, counted and identified (using the method of Jenkins et al., 1964); additionally, trophic guilds were determined using the criteria of the work of (Yeates, Bongers, De Goede, Freckman and Georgieva, 1993). The data were analyzed by comparisons of means through Tukey's test at a confidence level of 95%. For this purpose, the PSPP public license statistical software was used (Plaff, Darrington, Stover & Hakan, 2011).

**Table 1.** Sample collection design with their treatments subjected to in situ burning

| Site (T) | Depth | Treatment | | |
|---|---|---|---|---|
| | | **AQ** | **IDQ** | **MDQ** |
| T0 (control) | 0 a 7,5 | 3 samples | 3 samples | 3 samples |
| | 7,5 a 15 | 3 samples | 3 samples | 3 samples |
| T1 | 0 a 7,5 | 3 samples | 3 samples | 3 samples |
| | 7,5 a 15 | 3 samples | 3 samples | 3 samples |
| T2 | 0 a 7,5 | 3 samples | 3 samples | 3 samples |
| | 7,5 a 15 | 3 samples | 3 samples | 3 samples |
| T3 | 0 a 7,5 | 3 samples | 3 samples | 3 samples |
| | 7,5 a 15 | 3 samples | 3 samples | 3 samples |

Note: **AQ** (Before burning) **IDQ** (Immediately after burning) & **MDQ** (30 days after burning)

Source: self made

## 3. RESULTS AND DISCUSSION

### 3.1. Description of the profile.

Two horizons of the studied soil were determined (Horizon A and Horizon B), which corresponds to a vertisol-type soil (Figure 2).

| PROFILE | SOIL HORIZON | GENERIC HORIZON | OBSERVATIONS AND CHARACTERISTICS |
|---|---|---|---|
|  | A | 0.00m<br>Ap<br>0.32m | Clay texture, Color: Dry (10YR3/3), Angular and subangular blocky structure, Fine class, Grade: Weak. Very hard dry consistency, plastic and sticky when wet, organic matter content if there is reaction to H202, no reaction to 10% HCl. There is no presence of carbonates. |
| | B | Btpl<br>0.95m | Clay Texture, Color: Dry (10YR3/4), Structure type: angular blocks, class: fine, grade: moderate to strong, Very hard to extremely hard dry consistency, friable when wet, very plastic and adherent, Material content Minimal organic reaction to $H_2O_2$, no reaction to 10% HCl. There is no presence of carbonates. |

**Figure 2.** Characteristic profile of the soil horizons
Source: self made

The physical parameters that were negatively affected after the effects of burning at a depth of 0.0 to 7.5 cm, were the natural moisture content, the real density (ρr), apparent density (ρa), porosity, percentage of clay and silt (some significantly $\alpha$=0.05) (Table 2). Regarding the depth from 7.5 to 15 cm, the parameters related to the natural moisture content, the real density (ρr), the bulk density (ρa), the porosity and the clay percentage were negatively affected (some significantly α=0.05) (Table 2).

**Table 2.** Effects of burning on the different physical parameters, before (AQ), during (IDQ) and 30 days after burning (MDQ)

| Parameter | Treatment | N | 0 to 7.5 cm | | | 7.5 to 15 cm | | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean | E. Dev. | D. Tukey | Mean | E. Dev. | D. Tukey |
| % Moisture | AQ | 3 | 22,91 | 1,55 | a | 22,59 | 2,57 | a |
| | IDQ | 3 | 14,8 | 1,93 | b | 16,85 | 0,68 | b |
| | MDQ | 3 | 18,74 | 0,83 | c | 19,33 | 1,15 | ab |
| ρa | AQ | 3 | 1,64 | 0,04 | a | 1,68 | 0,02 | a |
| | IDQ | 3 | 1,68 | 0,05 | a | 1,68 | 0,03 | a |
| | MDQ | 3 | 1,71 | 0,06 | a | 1,71 | 0,04 | a |
| ρr | AQ | 3 | 2,4 | 0,06 | a | 2,34 | 0,04 | a |
| | IDQ | 3 | 2,25 | 0,04 | b | 2,25 | 0,05 | a |
| | MDQ | 3 | 2,23 | 0,01 | b | 2,27 | 0,07 | a |
| Porosity | AQ | 3 | 31,5 | 3,36 | a | 28,4 | 2,07 | a |
| | IDQ | 3 | 25,32 | 1,15 | ab | 25,24 | 0,98 | a |
| | MDQ | 3 | 23,55 | 3,03 | b | 24,89 | 3,61 | a |
| % Sand | AQ | 3 | 18,36 | 1,27 | a | 19,75 | 0,83 | a |
| | IDQ | 3 | 21,72 | 1,27 | a | 21,44 | 1,27 | a |
| | MDQ | 3 | 21,94 | 1,73 | a | 20,56 | 1,27 | a |
| % Clay | AQ | 3 | 44,72 | 1,74 | a | 44,44 | 1,27 | a |
| | IDQ | 3 | 42,22 | 0,48 | ab | 43,33 | 0 | a |
| | MDQ | 3 | 41,64 | 0,48 | b | 43,3 | 0,48 | a |
| % Silt | AQ | 3 | 36,92 | 0,84 | a | 35,81 | 1,93 | a |
| | IDQ | 3 | 36,06 | 1,27 | a | 35,22 | 1,27 | a |
| | MDQ | 3 | 36,41 | 1,44 | a | 36,14 | 0,96 | a |

Note: Different letters indicate significant difference according to Tukey's test (α=0.05)
Source: self made

For the chemical parameters at depths of 0.0 to 7.5 cm, only the percentage of natural moisture, the percentage of organic matter (%OM) and the cation exchange capacity (CEC) were negatively affected after being subjected to burning (some significantly at α=0.05) (Table 3), the opposite occurred with the pH that increased; the same thing happened at depths of 7.5 to 15 cm, with all the chemical parameters mentioned above.

**Table 3.** Effects of burning on chemical properties before (AQ), during (IDQ) and 30 days after burning (MDQ).

| Parameter | Treatment | N | 0 a 7.5 cm | | | 7.5 a 15 cm | | |
|---|---|---|---|---|---|---|---|---|
| | | | **Mean** | **E. Dev.** | **D.Tukey** | **Mean** | **E. Dev.** | **D.Tukey** |
| pH | AQ | 3 | 5,32 | 0,09 | a | 5,55 | 0,22 | a |
| | IDQ | 3 | 7,12 | 0,69 | b | 5,6 | 0,1 | a |
| | MDQ | 3 | 6,59 | 0,06 | b | 6,8 | 0,09 | b |
| MO | AQ | 3 | 2,79 | 0 | a | 2,81 | 0,14 | a |
| | IDQ | 3 | 2,71 | 0,03 | a | 2,68 | 0,02 | a |
| | MDQ | 3 | 1,53 | 0,18 | b | 2,25 | 0,1 | b |
| CIC | AQ | 3 | 25,88 | 1,51 | a | 25,17 | 0,29 | a |
| | IDQ | 3 | 24,33 | 0,76 | a | 24,67 | 0,58 | ab |
| | MDQ | 3 | 23,5 | 0,5 | a | 22 | 1,8 | b |

Note: Different letters indicate significant difference according to Tukey's test ($\alpha$ =0.05)
Source: self made

The soils that have been treated with burning, caused a proliferation and predominance of the nematodes of the guild belonging to the phytophagous, with a percentage increase to more than 90% as can be seen in Figure 3.

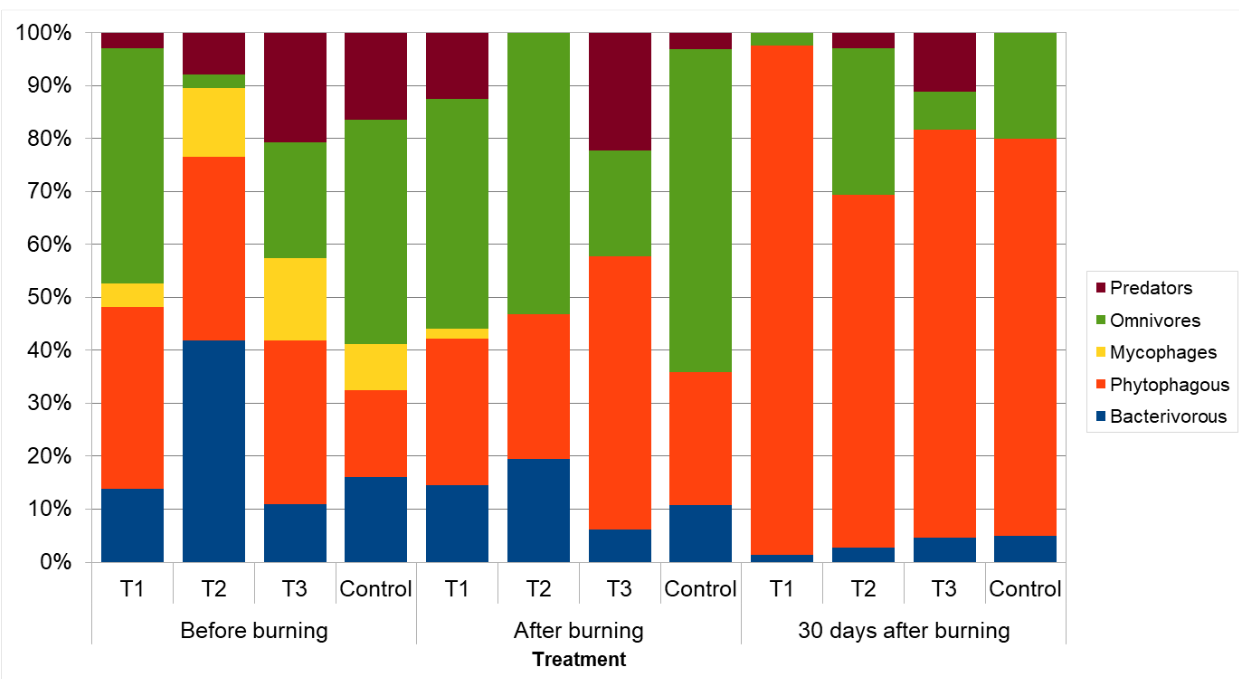


**Figure 3:** Percentage distribution of the different trophic guilds, before and after the burning

## 4. DISCUSSION

The results of the different percentage values of sand, silt and clay present in the different treatments, presented a little significant variation at the level of their classification, since they do not change their taxonomic characteristics, classifying as usually vertisol types. The texture of the soil does not change after a controlled burn, it is something natural permanently (Hillel 2013). The textural changes in these types of soils will depend on the continuity of the burning and the degree of temperature to which they are subjected and depending on the fuel material that is taken. Soil texture components (sand, silt, and clay) have high temperature thresholds and are not generally affected by fire unless they are subjected to high temperatures at the mineral soil surface (DeBano, Neary, & Ffolliott 1998). ). Fire and soil heating can destroy the soil structure, affecting the total porosity, as well as the pore size distribution of the surface horizons of the soil (Debano et al. 1998). These changes in organic matter decrease both the total porosity and the pore size, causing losses in the macropores in the soil surface, reducing water infiltration and producing a flow effect in the soil. Disturbance of organic material can also lead to a water-repellant soil, because the infiltration rate is further decreased (DeBano 1991).

The increase in soil pH is generally temporary, depending on the original pH, the amount of ash released, the chemical composition of the ash, and the humidity of the climate (Wells et al. 1979). The loss of cation exchange capacity (CEC), as a result of soil organic matter destroyed by the effect of fires, has been reported by several authors such as Soto and Diaz-Fierros (1993), who intensively monitored the exchange of soil cations with increasing burning temperature.

The increase in the percentage of phytophagous nematodes is due to the fact that organic matter is reduced by the effect of burning, since organic amendments, as well as organic enrichment of the soil, is an effective control for phytophagous populations such as demonstrated Badra, Saleh and Oteifa (1979); Muller and Gooch (1982); Rodriguez-Kabana (1986); Rodriguez-Kabana, Morgan-Jones, and Chet (1987). Kimenju, Muiru, Karanja, Nyongesa, Miano and Mutua (2004), showed excellent results on bean (Phaseolus vulgaris) plantations. Therefore, organic matter in the presence of moisture begins to decompose due to the action of cellulolytic bacteria that degrade plant remains, thus lowering the pH of the soil, making it acidic in nature, directly and indirectly affecting the populations of plants. Phytophagous nematodes (Norton, 1989).

## 5. CONCLUSIONS

-Most of the soil's physicochemical parameters studied had significant variations at shallow depths (from 0 to 7.5 cm), but according to several authors' references, in relation to the parameters of said properties, in some cases they do not suffer any change due to burning effects.

-The physical parameters, such as the natural moisture content, the real density, the porosity and the clay percentage of the soil studied, had significant decreases, due to the effects of the burning to which they were subjected at a depth of 0 to 7 .5cm

-The physical parameters, such as bulk density and the percentage of sand in the soil studied, increased due to the effects of burning (at a depth of 0 to 7.5 cm), where it was shown that the percentage of sand did not increase significantly.

-The chemical parameters, such as the percentage of organic matter (% OM) and the cation exchange capacity (CEC), at the depth of 0 to 7.5 cm, decreased significantly due to the effects of the burning to which they were subjected.

-At the depth of 7.5 to 15 cm; physical properties, such as bulk density, true density, porosity, and textural fractions such as sand, silt, and clay; they had no significant change due to the effects of burning.

-Chemical properties, such as pH and organic matter content, underwent significant changes, increasing and/or decreasing their values, when subjected to in situ burning (at depths from 0 to 7.5 and from 7. 5 to 15 cm).

-The cation exchange capacity (CEC), did not have significant variation at the depth of 0 to 7.5 cm, but it did at the depth of 7.5 to 15 cm, at 30 days after burning.

-Due to the effects of burning, the trophic diversity of free-living nematodes in the soil was negatively affected, favoring the proliferation of phytophagous nematodes, which could potentially become crop pests.

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