

**EFFECT OF BURNING TEMPERATURE ON SOME PROPERTIES AND FORMS OF IRON AND ALUMINUM OXIDES IN SELECTED SOIL TYPE IN DELTA STATE, NIGERIA.**

**H. O. EKUASE**

Department of Soil Science, University of Benin, Benin City

Email: ekuaseoghogho@yahoo.com

**ABSTRACT**

The study was carried out at Ughelli in Delta State to determine the effect of fire/heat as a means of clearing land on some physico-chemical properties of the soil particularly its effect on the oxides of iron and aluminum which abound in the soils of Southern Nigeria. The study was carried out in two phases. The first being to determine temperature ranges occurring when the farmers burn their farms and second to simulate such temperature ranges in the laboratory and find out the effect of such temperatures on the physico-chemical properties of the soil. The soil used is an Oxisol from Ughelli. The treatments in the first experiment were no burning, light burning, medium burning and heavy burning. Soil thermometers were installed in each plot before burning and temperatures recorded were ambient (25°C), 35°C, 102°C and 400°C respectively. In the second experiment, 200g soil samples collected from Ughelli were heated in the oven at ambient (27°C), 35°C, 102°C and 400°C such as found in forest fires. The samples were cooled and analyzed for physico-chemical properties. Results obtained showed that slight burning improved the nutrient content of the soils irrespective of soil type while severe burning (400°C) irrespective of soil nutrient supply affected the physical properties of the soils. There were no significant differences between 35°C and 102°C burning in terms of nutrient content and oxide composition whereas at 400°C the oxides were transformed from the amorphous forms to the crystalline forms which increased the quantity of coarse fractions of the soil particles. It is recommended that farmers can burn lightly as a means of clearing their farms but burning too much vegetation may cause unwanted changes in oxide composition and nutrient supply to crops.

**Keywords:** iron oxides, aluminium oxide, effect, temperature

**INTRODUCTION**

Fire plays an important role in both the preservation and evolution of ecosystems (Cohen, 2003). Moreover, a disproportionate amount of research on wetland fires has focused on the recovery of flora and fauna relative to a biotic change that can subsequently influence these processes (Abrahamson, 1984). Typically, fire alters the concentrations of soil nutrients, although the nature of these alterations can be quite variable. Marion, Moreno, Oechel (1991). In some cases, nutrient levels increase after fire, while in others no

enrichment occurs (Lanbhan, 1995). Alternatively, nutrients may be lost through volatilization, leaching, and or export of ash particles by up drafts of wind during the burning process. Traditionally, slash and burn has been the cheapest method for preparing both new land and forest re-growth for cultivation. Farmers also use this method for adding nutrients to the soil in no-fertilizer agriculture and destroying pests and diseases. Traditional slash and burn method produced more favourable changes in soils' physical and chemical properties and crop yields. Although burning increased the supply of exchangeable bases and available phosphorus, there is dearth of information on the effect of burning on trace metals. Heating of soil has an unquestionable effects on its chemical properties but may have varying of both beneficial and detrimental effect on soil fertility and the growth of plant, these effects depends on the type of soil, the temperature level at which the soil is heated, the length of heating and the species of plant (vegetation) grown on the heated soil.

In addition, the soils of South Western Nigeria are humid and rich in oxides and hydroxides of these trace metals particularly Iron, aluminum and manganese. These oxides and hydroxides control the chemistry of the humid tropical soils (Swift Ellis and Hakonson, 1986, Ghuman and Lal, 1987). There are three major soil types in South Western Nigeria which are the Ultisols, Oxisols and Alfisols. These soil groups are dominated by the oxides of these trace metals (Vale, 2002).

**OBJECTIVES OF THE STUDY**

The objectives of the study were to determine;

- The effect of different burning temperatures on the physico-chemical properties including extractable soil Fe and Al in the laboratory and to simulate temperature variations found during "slash and burn" in farmers' fields.
- Ideal burning temperature that will reduce unfavourable chemical and physical changes particularly the soil oxide components.

**MATERIALS AND METHODS**

In order to ascertain soil temperatures corresponding to burning of farmer's fields, four burning regimes were selected- No burning (control); light burning, medium burning (immature fallow) and heavy burning (forest vegetation).

**Experiment 1**

A site was selected in the old Faculty of Agriculture Farm with fallow re-growth of more than ten years

old. The site was divided into three blocks with each block containing four plots of 10 X 15m. Four treatments, No burning (control), light burning, medium burning and heavy burning were allocated to the plots randomly. In between each plot, a space of 2 metres was cleared completely of vegetation to prevent fire from spreading from one plot to the other. All the vegetation in various plots was cut and heaped in the plots and left to dry. Soil thermometers were buried in the plots to record soil temperature at the time of burning.

At the time of burning, all the biomass removed from the no burning plots was transferred to the high burning plots to simulate forest conditions. Also most of the woody materials in the light burning plots were transferred to the medium burning plots. The plots were carefully burnt one after the other and soil temperature noted immediately after each burning. The temperatures (35°C, 102°C and 400°C) were used for determining heating temperatures in the oven.

### Experiment 2

One (1) kg sample of surface soil from the Oxisol from Ughelli in Delta State and were collected for the second phase of the study. Each sample was divided into four and heated in the oven to 35°C, 102°C and 400°C while the control was air dried at ambient temperature. The experiment was carried out in triplicate. At the end of the heating, the samples were removed, cooled in a desiccator and analyzed for particle size, pH, organic carbon, total nitrogen, available phosphate, exchangeable bases, crystalline and amorphous oxides of iron and aluminum. The choice of locations and soil characterization was guided by Uzu, Orimoloye and Ugwa, 2003.

### Statistical Analysis

The data collected during the experiments were subjected to the analysis of variance (ANOVA) using the randomized complete block design. Mean were separated where there were significant differences using Duncan Multiple Range Test (Alika 2006).

### Determination of physical and chemical properties:

**Determination of soil pH:** The soil pH was determined at a soil to water ratio of 1:1 using a glass electrode pH meter.

**Determination of particle size analyses:** Particle size analyses were determined by the hydrometer method of Bouyoucos (1951).

**Determination of organic carbon:** The organic carbon content of the soil was determined by using

the chromic acid ( $K_2Cr_2O_7 + \text{concentrated } H_2SO_4$ ) wet oxidation procedure as described by Jackson (1962).

**Determination of total nitrogen:** The nitrogen was determined by micro-kjeldahl procedure as described by Jackson (1962).

**Determination of exchangeable bases:** The exchangeable bases extracted using IN neutral ammonium acetate solution and Ca and Mg content of the extract determined volumetrically by the Atomic Absorption Spectrophotometer (AAS) while K and Na were determined by flame photometry. Magnesium content and calcium were also determined by AAS while K and Na were analyzed by flame photometry.

**Determination of exchangeable acidity:** This was determined by IN KCL extraction and was determined by titrimetry methods of Mclean (1965).

**Determination of effective cation exchange capacity:** The effective cation exchange capacity and base saturation were computed as the sum of exchangeable bases (Ca, Mg, K, and Na) and exchangeable acidity.

**Determination of available phosphorus:** The available phosphorus was extracted by using Bray 1 solution, and the P in the extract assayed calorimetrically by the molybdate blue colour method of Murphy and Riley (1962).

**Determination of aluminum and iron oxides:** The determination was by x-ray diffraction theory methods of Brindley and Brown, (1980).

## RESULTS

### Effect of heating on particle size fractions

Temperatures recorded for Light burning was 35°C, medium burning 102°C and heavy burning 400°C. Control temperature was taken as ambient temperature (28°C). The results of the effect of simulated burning temperature on the soil studied are presented in Tables, 1 and 2. Values presented are means of triplicates. In the soil studied, Ughelli (Oxisol), there were no significant differences ( $P > 0.05$ ) in the quantities of silt and clay fractions for the air dried soil, light burning (35°C), and medium burning (102°C). However, at heavy burning (400°C) there was significant decrease ( $P < 0.05$ ) in the clay fraction and but not in the sand fraction.

**Table 1: Pretreatment status of soil used**

Property	Oxisol %
pH(1:1)H <sub>2</sub> O	4.02
Organic Carbon (g kg <sup>-1</sup> )	4.67
Total Nitrogen (g kg <sup>-1</sup> )	0.33
Available Phosphorus (mg kg <sup>-1</sup> )	1.31
Exchangeable Bases (cmol kg <sup>-1</sup> )	
Ca <sup>++</sup>	0.37
Mg <sup>++</sup>	0.10
K <sup>+</sup>	0.40
Na <sup>+</sup>	0.06
Exchangeable Acidity (cmol kg <sup>-1</sup> )	3.85
ECEC (cmol kg <sup>-1</sup> )	4.41
Dithionite -Citrate Fe	8.02
Oxalate Fe	1.37
Dithionite-Citrate Al	3.71
Oxalate Al	0.807
NH <sub>4</sub> -Acetate Fe	0.014
NH <sub>4</sub> -Acetate Al	0.023
Sand	86.33
Silt	1.00
Clay	12.67

---

Means of triplicate values

**Table 2: Effect of heating on particle size fractions of Oxisol (Ughelli)**

TREATMENT (°C)	SAND	SILT	CLAY
	←————— % —————→		
Air dried (Control)	86.33a	1.00b	12.67a
35	86.33a	1.00b	12.33a
102	87.00a	0.66b	12.33a
400	87.67a	2.33a	10.00b

Mean values with the same letter in the column are not significantly different from one another at 5% level of probability. There was no change in the silt proportion of the soil (Oxisol). In the Oxisol (Ughelli) there was no change in the soil particle fractions except at 400°C where the change was between the silt and clay fractions.

#### Chemical properties as affected by heating.

Table 3 show the chemical properties of the soil as affected by the slash and burn temperature. In the Oxisol (Ughelli) (Table 4) heating caused statistically significant increase ( $P > 0.05$ ) in pH from control (6.30) and then a decline in pH to a value of 6.02 at 35°C.

The chemical properties of the Oxisol as affected by burning temperature are presented in Table 4. Heating caused a statistically significant increase ( $P > 0.05$ ) in pH from control (6.30) to 35°C and then a decline in pH to a value of 6.02. In the Oxisol (Table 3) there was an increase from the control (pH 4.02) to 4.99 at 102°C but there was no significant difference ( $P < 0.05$ ) in pH between 102°C and 400°C. There was a general rise in pH of the soil with increase in temperature. In the Oxisol, with very little organic carbon content (4.67 g kg<sup>-1</sup>), there was no significant loss ( $P > 0.05$ ) of organic carbon at 35°C, a slight loss at 102°C and a highly significant loss at 400°C. At this temperature, about 80% of the organic carbon of the soil was destroyed.

**Table 3: Effect of heating on some chemical properties of an Oxisol (Ughelli)**

PROPERTY	TREATMENT			
	Control	35°C	102°C	400°C
pH(l:l)H <sub>2</sub> O	4.02c	4.53b	4.99a	4.80a
Organic Carbon (g kg <sup>-1</sup> )	4.67a	4.63b	4.23b	4.97c
Total Nitrogen (g kg <sup>-1</sup> )	0.33ab	0.40a	0.30b	0.17c
Av.P (mg kg <sup>-1</sup> )	1.31d	1.55c	1.86b	2.09a
Exch. Bases (cmol kg <sup>-1</sup> )				
Ca <sup>++</sup>	0.37d	0.40c	0.48b	0.50a
Mg <sup>++</sup>	0.10a	0.11a	0.12a	0.11a
K <sup>+</sup>	0.40a	0.05a	0.04a	0.04a
Na <sup>+</sup>	0.06ab	0.06a	0.05b	0.03c
Exch. Acidity (cmol kg <sup>-1</sup> )	3.85a	3.48b	2.95d	3.19c
ECEC (cmol kg <sup>-1</sup> )	4.41a	4.11b	3.63d	3.87c

Mean values with the same letter in the row are not significantly different from one another at 5% level of probability. In the Oxisol, there was no significant difference between the nitrogen level of the control and 35°C soil temperature but at higher temperatures, soil nitrogen decreased rapidly reaching a low level of 0.17 g kg<sup>-1</sup> representing a 49% loss in soil N. There was a slight decrease between the control and slight and medium burning but at 400°C there was an increase in phosphate level. In the Oxisol, there were significant increases in available phosphorus level from control 1.31 mg kg<sup>-1</sup>, 1.55 at 35°C, 1.86 at 102°C and 2.09 mg kg<sup>-1</sup> at 400°C representing a 60% increase over the control. At 400°C the increase was

about 46% over the control. The exchangeable bases of the soil as influenced by burning temperature are shown in Table 4. In the Oxisol (Ughelli) burning increased the Ca levels significantly, decreased the exchangeable acidity and decreased the effective cation exchange capacity (ECEC). There was no significant change in the levels of Mg<sup>2+</sup>, Na<sup>+</sup> and K<sup>+</sup> with increase in burning temperature.

#### Effect of heating on some soil oxides

A study of the effect of burning intensity on the levels of crystalline, amorphous and exchangeable forms of Iron and aluminum in the three soils and results obtained are shown in Table 4.

**Table 4: Effect of heating on some soil oxides of Oxisol (Ughelli)**

PARAMETERS	TREATMENT			
	Control	35°C	102°C	400°C
Dithionite-Citrate Fe (%)	8.02c	8.14c	8.56b	9.36a
(Crystalline)				
OxalateFe(%)	1.37b	1.59a	1.19c	0.11d
(Amorphous)				
Dithionite-Citrate Al (%)	3.71c	3.69c	4.50b	5.06a
(Crystalline)				
OxalateAl(%)	0.81b	0.92a	0.53c	0.02d
(Amorphous)				
NH <sub>4</sub> <sup>+</sup> Acetate Fe (%)	0.01a	0.01b	0.00c	0.00c
NH <sub>4</sub> <sup>+</sup> Acetate Al (%)	0.02a	0.02a	0.00b	0.00b

Mean values with the same letter in the row are not significantly different from one another at 5% level of probability. In the soil, burning at 35°C had little or no effect on the dithionite-citrate extractable iron and aluminum (crystalline forms) while at temperatures 102°C and 400°C there was a general increase in the crystalline forms. With the Oxalate extractable (amorphous Iron and aluminum) and ammonium acetate extractable (exchangeable Fe and Al) forms, there was a general decline with increase in burning temperature.

#### DISCUSSION

The soil collected from Oxisol (Ughelli) is highly acidic with excellent granular structure and low base

saturation. Generally all the soils used possess low fertility status. Heavy fertilization, especially with phosphorus rich materials is often required in Oxisols (Beyers, 2004).

#### Effect of Burning Temperature on Physical Properties of Soils

The effect of burning temperature on the textural composition of the soils was studied. There were no statistically significant differences ( $P > 0.05$ ) in the sand fraction of the various soils at low burning temperatures (Control, 35°C, and 102°C) but at high temperature (400°C) and above there was a statistically significant difference ( $P < 0.05$ ) between the Control and 400°C in all the soils. The increase in

sand fraction may be related to the crystallization of amorphous oxides of iron, aluminum and manganese common in these soils into hard crystalline oxide nodules at high temperatures. These nodules may have settled as coarse particles, thus increasing the sand fraction (Araki, 1993).

In Ughelli samples, the silt contents were not significantly different among all the treatments. At 102°C, the percentage silt value was 7.33% recorded at Ughelli and increased marginally to 8.00% at 400°C. The reason for this increase is not clear. However, Fernandes *et al.*, (1999) suggested that, loss of crystal lattice OH as H<sub>2</sub>O and CO<sub>3</sub><sup>2-</sup> as CO<sub>2</sub>, which normally occur at high temperatures may account for the marginal increase. The decrease in the value of clay with higher temperature regime in all the soils was probably due to crystallization of Iron, aluminum and manganese oxides, which form major components of the clay fraction of these soils and loss of soil moisture and organic matter due to high temperature may result in disintegration of soil aggregates and an increase in the coarse particles, particularly sand fraction with a corresponding decrease in clay content (McKee, 1982); De Beno *et al.* (1998).

#### **Effect of Burning Temperature on Soil pH**

The increase in soil pH in the three soils may be due to the fact that, as temperature increased microbial activities initially will increase, mineralizing organic matter thereby releasing carbonates, bicarbonates and ammonia (Klopatek, Friese, Alien, 1994). Also Riley, Crozier, Blong *et al.* (1981) observed that with initial mineralization of OM, resulting HCO<sub>3</sub><sup>-</sup> and NH<sub>4</sub><sup>+</sup> may lead to increase in pH. At high temperatures, not only will the soil microbes be killed but also a shift in the oxidation state of some of the oxides like Fe and Al will result in the reduction of soil pH. Similar result have earlier been obtained by Neary *et al.*, (1990) who reported that, elevated pH is the usual situation following fire at least in the few surface centimeters (cm) of soil. However, in highly acidic soils like Oxisol (Ughelli), it's soil pH increased because of the release of OH<sup>-</sup> ions when Fe (OH)<sub>2</sub> and similar compounds were oxidized to Fe (OH)<sub>3</sub> or Fe<sub>3</sub> (OH)<sub>8</sub> (Stephens, 1998).

#### **Effect of Burning Temperature on Organic Matter**

The mineralization of organic matter in soils is a function of temperature. Combustion of organic matter is a rapid decomposition process in which oxidation changes the form of carbon (C). In the experiment, heating of the soil at 400°C resulted in the organic matter in the soil to be volatilized or got burnt off which resulted in drastic drop in the organic matter content. DiTomasso, Kyser, Hastings *et al.* (2001) and Cohen, (2003) found that at such high temperatures, organic carbon volatilization and transformation with release of OH<sup>-</sup> into the soil

resulted in pH increase. Also DeBano (1998) suggested that at temperature above 180°C there is loss of soil organic matter (SOM) as the soil temperature becomes hotter due to volatilization of soil organic constituents.

#### **Effect of Burning Temperature on Total Nitrogen**

Total Nitrogen is a major constituent of soil organic matter (Black, 1965, Sparks, 2003). A decrease in soil OM would obviously result in decrease in total nitrogen. Nitrogen can be lost through denitrification at lower temperatures, volatilization at medium (35-102°C) and oxidation at high temperatures (102-400°C). All the forms of Nitrogen (NO<sub>2</sub>, NO<sub>3</sub>, NH<sub>4</sub> and their organic compounds are lost at medium to high temperatures. In Ughelli samples analysed, total nitrogen declined with increase in temperature. The studies of Crutzen and Neary, Folliott, *et al* (1999); DeBano *et al.*, (1998) and Anderson and Menges (1997) further showed that, burning released a considerable amount of carbon and nitrogenous compound into the atmosphere and nitrogen can volatilize into the atmosphere at 200°C resulting in total loss of soil nitrogen. The decrease in the value of the total nitrogen with increased temperatures may also be attributed to the dissolution of the nitrogenous base salts such as Ammonium salts (NH<sub>4</sub><sup>+</sup>), Nitrite salts (NO<sub>2</sub><sup>-</sup>) and Nitrate salts (NO<sub>3</sub><sup>-</sup>) to form soil solution (NO<sub>x</sub>) and subsequently lost into the atmosphere as earlier reported by Ballard, (2000); Garcia and Latterra, (2003) and Snyman, (2003).

#### **Effect of Burning Temperature on Available Phosphorus**

There was a general increase in available P as a result of heating. The increase in P compounds may be due to the fact that, P generally are not volatile as reported by Raison *et al.* (1995) and that, fire, increases the mineralization rates of organic phosphorus through its impact on soil microorganisms as reported by Blair and Scharz, 1997. The increase is attributable to release of organic P from organic matter and decomposition of P bearing minerals in the soil at high temperatures. (Ojima and Owensby, 1994).

#### **Effect of Burning Temperature on Exchangeable Cations of the Soils**

##### **Effect of Burning Temperature on Calcium**

Decomposition of organic carbon by heat leads to release of nutrients at control and medium temperatures but at higher temperatures, ashing of the organic carbon takes place with corresponding deposition of Ca, Mg, and K as ash.

##### **Effect of Burning Temperature on Magnesium**

The decrease in Mg in Oxisol, is due to the fact that the numerous simple salts of magnesium such as

magnesium sulphate and magnesium chloride dissolved in the soil solution and escaped or volatilized into the atmosphere during burning. Similar results had earlier been reported by (White *et al.*, 2004).

#### **Effect of Burning Temperature on Potassium**

Potassium requires greater than 700°C for volatilization and its loss is usually minimal unless the fire is followed by erosion. (White and Zak, 2004). In Ughelli samples, there was a decrease in potassium level with increasing temperature (102°C-400°C) regimes due to specific adsorption into the inner surfaces of silicate clay minerals, particularly hydrated micas, kaolinite and illite (Kutiel and Naveh, 1987).

#### **Effect of Burning Temperature on Sodium**

The sharp decrease of sodium in the three locations could be attributed to the higher temperatures which caused a swift volatilization of the sodium salts. Moreover, the higher temperature could have caused an increase in the percentage sodium saturation and also increased the concentration of hydroxyl ions in the soil solution which then increased the evaporation rate of the sodium salts like sodium chloride and sodium sulphate (Rundel, 1983).

#### **Effect of Burning Temperature on Exchangeable Acidity**

Basically, the decrease in exchangeable acidity after burning in Ughelli sample is most quantitatively accounted for by the increases in exchangeable Ca+Mg in the topsoil (Litton and Santelices, 2003). In the soils, the reduction in exchangeable acidity could also be attributed to the higher temperature regime which dislocates the hydrogen out of place which then became active in the soil, and then caused the acidity of the soil solution to be reduced (Lesica and Martin, 2003).

#### **Effect of Burning Temperature on Effective Cation Exchange Capacity (ECEC)**

Generally, the decrease in the level of ECEC in all the soils could be attributed to the breakage of the exchangeable sites of the plant's soil nutrients and breakage of the exchange sites of the soil colloids (Mills *et al.*, 2004).

#### **Effect of Burning Temperature on Soil Oxides**

##### **Effect of Burning Temperature on Dithionite-Citrate Fe and Oxalate Fe**

There was an increase in Dithionite-Citrate Fe with corresponding decrease in Oxalate Fe in the location studied (Table 4). The increase in the location could strongly be attributed to the fact that, Dithionite-Citrate Fe is naturally amorphous in nature and it would tend to increase its percentage values with a corresponding increase in temperature regimes. While Oxalate Fe are crystalline in nature which

automatically decreases in the percentage value with increasing temperature regimes (Fuleet *et al.*, 2004).

##### **Effect of Burning Temperature on Dithionite-Citrate Al and Oxalate Al**

Similar increase in the level of Dithionite-Citrate Al caused a corresponding decrease in the value of Oxalate Al at increasing temperature regimes as observed in this work. This phenomenon is attributed to the fact that, the Dithionite-Citrate Al appears in nature, as an amorphous oxide while Oxalate Al is in a crystalline form and when an amorphous compound are exposed to higher temperature, it's percentage values increased. Also when a crystalline compound are equally exposed to higher temperature, it's percentage values decreased as also reported by FrancoVizcaino *et al.* (1997).

##### **Effect of Burning Temperature on NH<sub>4</sub><sup>+</sup> Acetate Fe and NH<sub>4</sub><sup>+</sup> Acetate Al**

The sharp decrease in the values of NH<sub>4</sub><sup>+</sup> Acetate Fe and NH<sub>4</sub><sup>+</sup> Acetate Al in the soil was attributed to the fact that, it has undergone volatilization due to high temperature regimes (Hall, 1986).

#### **CONCLUSION AND RECOMMENDATION**

The study indicates that, burning of vegetation with its corresponding temperature regimes often produce variable results in terms of nutrient availability in the soils. Slash and burn as practiced in traditional agriculture affects the chemistry of the soil depending on the severity of the burn. In burning at 35°C - 400°C there is loss of organic matter, decrease in soil acidity and loss of total nitrogen. It also leads to conversion of soil oxides from amorphous to crystalline forms which decrease the ability of the soils to sorb nutrients particularly phosphorus. It is therefore desirable that burning temperature should be such as to improve soil fertility and reduce oxide transformation.

Farmers are sometimes reluctant to use fire as a tool because of the potential negative impacts on soil properties. However, careful burning and judicious selection of sites can mitigate these risks. The most severe long-term effects of fire will occur where erosion removes topsoil, but the risk of erosion can be reduced by burning only small areas when treating on steep hills, or avoiding burning altogether in steep terrain in favour of other weed control measures. Along with erosion, farmers are concerned that hot fires will alter soil chemical, physical and biological properties. Only the hottest fires, as under slash piles or fire-suppressed vegetation with high litter build-up, will cause long-term changes in soil chemical, physical and biological properties. Hot fire can be avoided by careful fuel control in advance of the fire. This has been done, for instance, in high-density ponderosa pine forests in northern Arizona, where pole-size trees were first removed before fire. It should be emphasized that this study is reporting

results obtained from a single fire event. However, the result of the study in Ughelli indicated that nutrients are mobilized following a fire and that some of the mobilized nutrients are lost in runoff or at least relocated down slope. Significant soil properties can also be altered, including dispersion characteristics that could lead to an increase in the erosion hazard.

Fire may be especially beneficial where vegetation have increased the litter layer and increased soil N. While there have been many studies on the effects of fire on N losses in natural vegetation, studies on use of fire to deplete elevated N in invaded systems are apparently still lacking. With the knowledge of fire temperatures and fuel loads needed to reduce surface N, fire seems like a viable method not only of controlling the vegetation as described in this work, but also of reducing elevated soil N. Studies are needed to determine the extent to which fire will restore soils with elevated N, C and soil oxides. Moreover, fire effects on the physical, chemical and oxides components of the duff and litter and mineral soil depend in part on the amount of fuel consumed. However, it is recommended that, prescribed/controlled burning is important for controlling soil heating and potential site productivity. It is also recommended that fallow immature forest (less woody vegetation) should be cultivated because it will naturally regulate the amount of material consumed during burning, the magnitude and duration of soil heating, the frequency of fire, and the post fire environment.

Finally, slight to medium burning should be encouraged by farmers for there were no significant difference among the soil properties i.e. physical, chemical and oxides. Although suggestions have been made to help account for these distributions, there is clearly a need for further experimental data to confirm them and relate them to other known soil properties

## REFERENCES

- Alika, I.E. 2006. *Statistics and Research Method*, 2nd ed. Ambik Press, P.209.
- Abrahamson, W. 1984. Species responses to fire on the Florida Lake Wales ridge. *American Journal of Botany*. 71:35-43.
- Anderson, R.C.; E .S. Menges, 1997. Effects of fire on sandhill herbs: Nutrients, mycorrhizae, and biomass allocation. *American Journal of Botany*. 84(7): 938- 948.
- Araki, S., 1993. Effect on soil organic matter and soil fertility of the chitemene slash-and-burn practice used in Northern Zambia. In: Mulongoy, K., Merck X, R. (Eds). *Soil organic matter Dynamics and Sustainability of Tropical Agriculture*. Wiley-Sayce, K.U. Leuven. pp. 367-375.
- Ballard, T.M. 2000. Impacts of forest management on Northern forest soils. *Forest Ecology and Management*. 133(1-2): 37-42.
- Beyers, J.L. 2004. Postfire seeding for erosion control: Effectiveness and impacts on native plant communities. *Conservation Biology*, 18(4): 947-956.
- Black, C. A. 1965. *Methods of soil analysis*. Agronomy No. 9 Part 2. America Society of Agronomy. Madison, Wisconsin.
- Bouyoucos, G. J. 1951. A recalibration of the hydrometer method for making Mechanical Analysis of soils. *Agronomy Journal* 43: 434-438.
- Brindley, G.W., and Brown, G., eds. 1980. "Crystal structures of clay minerals and their X-ray identification." Monogr.No. 5 Mineralogical Society, London.
- Cohen, A.D. 2003. *The Impacts of Fire on Ecosystems*. Available online at <http://www.micro.utexas.edu/courses/rncmurry/spring98/10/ierrv.html>.
- Crutzen, P.; M. Andreae, 1990. Biomass burning in the tropics. Impact on atmospheric and biochemical cycles. *Soil Science of America Journal* 250(4): 1669-1678.
- DeBano, L.F., D.G. Neary; P.F. Folliott. 1998. *Fire's effects on ecosystems*. John Wiley & Sons, New York, USA.
- DiTomaso, J.M., G.B. Kyser; M.S. Hastings. 2001. Prescribed burning for control of yellow starthistle (*Centaurea solstitialis*) and enhanced native plant diversity. *Weed Science* 47: 233-242.
- F.A.O. 2006. *Guidelines for soil profile description*. 19th ed. Food and Agriculture Organization, Rome.
- Fernandes, P.; Botelho, H.; Loureiro, C. 1999. Fire hazard implications of alternative fuel management techniques: case studies from northern Portugal. *The Joint Fire Science Conference and Workshop*.
- FrancoVizcaino, E.; J. SosaRamirez. 1997. Soil properties and nutrient relations in burned and unburned Mediterranean-climate shrublands of Baja California, Mexico. *Acta Oecologica-International Journal of Ecology*. 18(4): 503-517.
- Fule, P.Z.; A.E. Cocke, TA. Heinlein ; W.W. Covington. 2004. Effects of an intense prescribed forest fire: Is it ecological restoration? *Restoration Ecology*. 12(2): 220-230.
- Ghuman, B.S.; Lal, R. 1987. Effects of partial clearing on microclimate in humid tropical rainforest. *Agricultural and Meteorology*. 40: 17-29.
- Hall, R.G. 1986. The effects of fuel reduction burning on the physical and chemical properties of forest soils and the erosion

- hazard of these fires. M. Env. Sci. thesis, Monash University, Melbourne.
- Jackson, M. L. 1962. Soil chemical analysis. Prentice Hall, New York. 263-268.
- Klopatek, C.C.; C.F. Friese.; M.F. Alien.; J.M. Klopatek. 1994. Comparisons of laboratory and field burning experiments on mycorrhizae distribution, density and diversity. *Journal of the Society of American Foresters*. 94: 762-776.
- Swift, M., Ellis, J.E., and Hakonson, T.E., 1986. Immediate effect of prescribed burning on mineral soil nitrogen in Ponderosa Pine of New Mexico. *Soil Science* 141; 71-76.
- Kutiél, P.; Z. Naveh 1990. Soil properties beneath *Pinus-Halepensis* and *Quercus- Calliprinos* trees on burned and unburned mixed forest on Mt-Carmel, Israel. *Forest Ecology and Management*. 20(1-2): 11-24.
- Laubhan, M.K. 1995. Effects of prescribed fire on moist-soil vegetation and soil macronutrients. *Wetlands* 15:159-166.
- Lesica, P.; B. Martin. 2003. Effects of prescribed fire and season of burn on recruitment of the invasive exotic plant, *Potentilla recta*, in a semiarid grassland. *Restoration Ecology*. 11(4): 516-523.
- Litton, C.M.; R. Santelices. 2003. Effect of wildfire on soil physical and chemical properties in a *Nothofagus glauca* forest, Chile. *Revista Chilena de Historia Natural*. 76(4): 529-542.
- Marion. G.M., J.M. Moreno.; W.C. Oechel. (1991). Fire severity, ash deposition, and clipping effects on soil nutrients. *Canadian Journal of Soil Science*. 78(1): 93 -104. in chaparral. *Soil Sci. Am. J.* 55:235-240.
- Mckee, W.H. 1982. Changes in Soil Fertility following prescribed burning on coastal plain pine sites. Asheville, NC: 23p.
- McClean, E. O. 1965. Aluminum. In: *Methods of soil analysis*. (C.A. Black, ed.) *Agronomy No. 9 Part 2*. American Society of Agronomy. 978-998.
- Mills, A.J.; M.V. Fey. 2004. Frequent fires intensify soil crusting: physicochemical feedback in the pedoderm of long-term burn experiments in South Africa. *Geoderma*. 121(1-2): j45-64. I
- Murphy, J.; Riley. J.P. 1962. A modified single solution method for the determination of phosphate in natural water. *Annal. Chim. Acta*. 27: 31-36.
- Neary, D. G.; C.C. Klopatek; P.F. Folliott. 1999. Fire effects on belowground sustainability: a synthesis. *Forest Ecology and Management* 122:51- 71.
- Ojima, D.S.; D.S. Schimel; W.J. Parton.; C.E. Owensby. 1994. Long- and short-term effects of fire on nitrogen cycling in tallgrass prairie. *Biogeochemistry*. 24: 67-84.
- Garcia.; P. Laterra. 2003. Biological and chemical response of a grassland soil to burning. *Journal of Range Management*. 56(3):291-297.
- Raison, R.J., P.K. Kharmna ; P.V. Woods 1995. Mechanisms of element transfer to the atmosphere during vegetation fires. *Canadian Journal of Forest Research*. 15: 132-140.
- Riley, S.J.; Crozier, P.; Blong, R.J. 1981. An inexpensive and easily installed runoff plot. *Journal of the Soil Conservation Service NSW*, vol. 37, no. 3, 144 - 147.
- Rundel, P.W. 1983. Impact of fire on nutrient cycles in Mediterranean-type ecosystems with reference to chaparral. Pp, 192-220 in Kruger, F.J., D.T. Mitchell and J.U.M. Jarvis, eds. *Mediterranean-Type Ecosystems: The Role of Nutrients*. Springer-Verlag, New York,
- Snyman, H.A. 2003. Short-term response of rangeland following an unplanned fire in terms of soil characteristics in a semi-arid climate of South Africa. *Journal of Arid Environments*. 55(1): 160-180.
- Sparks, D.L. 2003. *Environmental Soil Chemistry*. Academic Press, San Diego, California. Pp, 200-245.
- Stephens, S.L. 1998. Evaluation of the effects of silvicultural and fuels treatments on potential fire behaviour in Sierra Nevada mixed-conifer forests. *Forest Ecology and Management*. 105: 21-35.
- Schartz R. J.; Blair, J. M.; Neel., 1997. Soil N and plant responses to fire, Topography and supplemental N in tallgrass prairie. *Ecology* 78:1832-1843.
- Uzu, P.O., Orimoloye, J.R and Ugwa, I.K. (2003), Paper presented at the 28th Annual Conference of the Soil Science Society of Nigeria (SSSN) held at Umudike, Abia State, Nigeria.
- Vale, T.R. (ed.). 2002. *Fire, native peoples, and the natural landscape*. Island Press, Washington, D.C. 238 pp.
- White, L.L.; D.R. Zak. 2004. Biomass accumulation and soil nitrogen availability in an 87-year-old *Populus grandidentata* chronosequence. *Forest Ecology and Management*. 191(1-3): 121-127.