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# The Effect of Burnt and Un-burnt Land on Soil Physicochemical Characteristics in Ekeya-Okobo Local Government Area, Akwa Ibom State, Nigeria

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**ABSTRACT:** Slash and burn method of land clearing is an integral part of the traditional farming system widely used as a means of land clearing to pave way for crop production in southern Nigeria. This management has both beneficial and detrimental effects on soil and its properties. Based on this, effects of fire on soil quality dynamics was examined during slashing and burning of the plots at the depths ranging between 0-15, 15-30cm respectively. *The soil sample point s* was chosen using a simple random sampling and the soil sampled were analyzed for the selected physical and chemical characteristics. ANOVA was used for significance difference between soil from burnt and unburnt plots using statistical package for social science (SPSS), and significant means were compared using Duncan multiple range test. Paired t-test was used to compare means of the unburnt and burnt plots. At the depth of 0-15cm, the unburnt plot recorded decrease in pH($H_2O$) 5.6, pH ( KCI)4.9, increase in sand, silt, K and base saturation, while burnt plot recorded increase in clay, SOC, SOM ,TN , Avail P., $Ca^{2+}$, $Mg^{2++}$, $Na^+$ and EC ($H^+$+$Al^{3+}$). At the depth of 15-30cm, unburnt plot recorded low pH in $H_2O$ and Kcl, silt, Mg and EC while burnt plot recorded highest values in other selected parameters than unburnt plot. Between the two plots sampled, changes of physical and chemical parameters were significant at the P :< 0.05 probability level, ($F_{tab}$ = 4.60 Fcal= 1.597Ω 1.6). Based on this, there is a need for environmental education for farmers in the area to know the implications of burning of farmland on soil ecosystem and environment as a whole for soil sustainability that will boost food production.

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***Keywords***: Burnt and un-burnt, Soil, physiochemical, agriculture, soil acidity.

The world has lost about half of its forests to agriculture and other uses, and 78 percent of what remains is heavily altered, bearing little resemblance to the original forests (Bryant et al. 1997). About 72 percent of the original 1450 million ha of tropical forests have been converted to other uses (FAO, 1997). Small-scale farmers often are viewed as the primary agents of deforestation (Hauck 1974), accounting for as much as 96 percent of forest losses (Myers, 1994)**.** Most studies of slash-and burn document increased soil nutrient availability after burning (De Rouw, 1994). Post-burn increases in soil fertility have been attributed to nutrient-rich ash in nearly all tropical forest types where slash-and-burn has been examined (Maass, 1995). Apart from the effects of burning on soil , it also has a marked increase in global warming due to the emission of $NO_2$, $SO_2$, $SO_3$, NO, CO and $CO_2$ gases which have tremendous effect on the Ozone layer ( Jamala et al, 2012), and viewed that bush burning causes changes in the micro-climate at the soil - atmosphere interface. McKnight (1992) argued that atmospheric carbon dioxide continues to be increased because, there are fever trees to absorb it and because burning of trees for forest cleaning releases more carbon dioxide to the atmosphere. It is currently believed that the earth's atmosphere is heating up due to increasing amounts of carbon dioxide and other gases resulting from human activities such as bush burning (Ambe et al, 2015).

Global carbon emissions have been estimated during the past three decades from slash and burn leading to the mission of $CO_2$ to the atmosphere (Mieville et al., 2010; Wiedinmyer et al., 2011). Forest burning is a net contributor to global warming, global warming results from an atmospheric buildup of greenhouse gases, primarily carbon dioxide. Of the carbon dioxide that we humans contribute, roughly two-thirds is from the burning of fossil fuels and one-third is from the burning of biomass, such as forests, grasslands and agricultural crops (Levy, 2004).An Environmental Scientist in her statement observed that:

"When the soil is burnt, its nutrients are destroyed and the soil is exhausted. And, when the grass is burnt, it releases carbon dioxide into the atmosphere thus contributing to the depletion of the ozone layer and to climate change. slash and burn' farming techniques are bad for both local agriculture and the environment and why the Durban conference must provide alternatives for small scale farmers" (Wendi, 2011).

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This statement was reemphasized by Leocadia who observed that in Cameroun:

"Rural women understand that slash and burn technique is unsustainable and that the soils are already damaged from this farming method. But they say that for them to change, they need an affordable alternative" (Leocadia, 2011).

In the Southern part of Nigeria, slash and burn method of land clearing is an integral part of the traditional farming system widely used as a means of land clearing to pave way to tillage (Neff et al., 2005; Jamala et al, 2012 ; Edem et al, 2013).

As more land is being cleared and prepared for cropping annually in humid tropics for food production , burning has become the easiest and most convenient method quite often employed (Ruddiman, 2003; Edem et al., 2012). Rates of nutrient loss from slash fires are among the highest of any fires (Kauffman et al., 1995), and sustaining site fertility depends on a detailed understanding of the nutrient fluxes and losses that accompany such fires. In Ekeya-Okobo, farm lands are cleared and fire is set indiscriminately by farmers without considering after effects on soil ecosystem and entire environment.

Therefore, the research is on the effect of burnt and Un-burnt land on Soil physicochemical characteristics in part of Akwa Ibom State for soil quality sustainability.

## MATERIALS AND METHOD

*Study area:* **E**keya is one of the villages in Odu clean, Okobo Local Government Area of Akwa Ibom State (Fig1). Ekeya is located in Longitude 8° 10' 53" East, Latitude 4° 51' 43" North and with the height of 26m above the sea level. The area is divided into two distinct seasons, the wet and dry seasons that spans between October and April and wet season which starts around May and ends in September. Ekeya - Okobo is in the tropical region and has a uniformly high temperature all the year round with evergreen rainforest (Fig.2), with about 2,878 mm of precipitation falling annually, with the average temperatures varying during the year by 2.3 °C (Edem et al., 2012) The native vegetation has been almost completely replaced by secondary forests of predominantly wild oil palms, woody shrubs and various grass undergrowth**.**

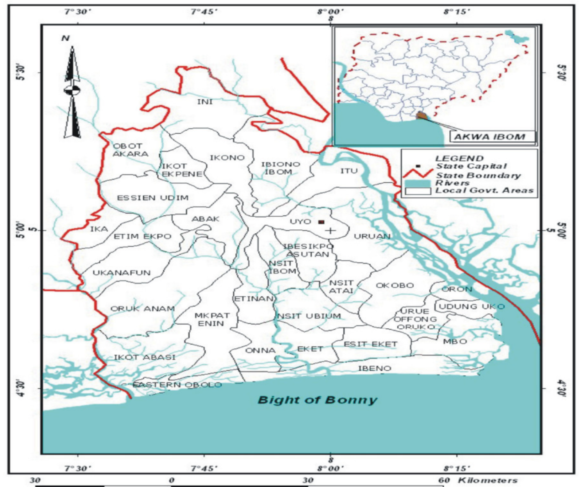


**Fig 1:** Map of Akwa Ibom State showing Okobo Local Government Area
Source: Charles et al, 2014

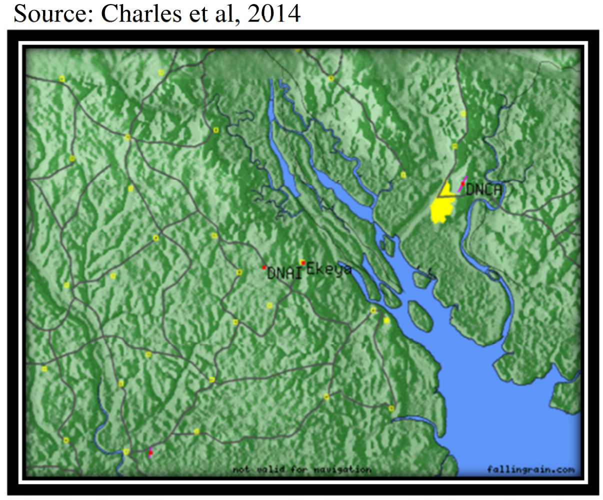


**Fig 2:** Satellite Image of Ekeya- Okobo: Google, 2016

*Fieldwork:* Traditional land preparation method was carried out by farmers using cutlass to slash the farmland and allowed to dry for three weeks before burning by the use of kerosene, fuel and without depending on the level of dryness .of the vast community owned land which is cultivated after 5 years of fallowing..

*Soil sample collection from Burn and un-burn plots:* The study was carried out on vast hectares of farmland traditional prepared during 2016 planting season in Ekeya. The trashes cleared were allowed to dry for about one month to maximize the intensity of the burn, a management objective believed by local farmers to be important for good crop yield. Immediately the land was cleared without burning, soil samples were collected and after indiscriminate burning of debris with the help of kerosene and fuel by farmers, soil samples were equally taken at the depths of 0-15cm, 15-30cm using auger. Soil samples were randomly picked from pre and post burn plot, bagged and labelled for the analysis.

*Laboratory analyses of the Physical and chemical parameters*: The particle size analysis was determined using hydrometer method in 5 % sodium hexametaphosphate as the dispersing agent (Bouyoucos, 1951). The pH of the soil was determined electrometrically using a pH meter in 1:1 soil – 1M KCl and 1:1 soil-water suspensions (Mclean, 1982). Organic matter was determined using Walkley – Black wet oxidation method (Nelson and Sommers, 1982). Total nitrogen of the soil was determined using the macro Kjeldahl method (Bremner and Mulvaney, 1982). Available phosphorus in the soil was determined using Bray P1 method (Olsen and Sommers, 1982). Exchangeable cations ($Ca^{2+,}$ $Mg^{2+,}$ $K^+$ and $Na^+$) were determined using 1M NH4OAc (Ammonium acetate) buffered at pH 7.0 as extractant (Thomas, 1982). The $K^+$ and $Na^+$ concentrations in soil extracts were read on Gallenkamp flame photometer while $Ca^{2+}$ and $Mg^{2+}$ concentrations in soil extracts were read using Perkin-Elmer Model 403 atomic absorption spectrophotometer (AAS). The exchangeable acidity ($H^{++}Al^{3+)}$ in the soil was extracted with 1M KCl (Thomas, 1982). Solution of the extract was titrated with 0.05M NaOH to a permanent pink endpoint using phenolphthalein as indicator. The amount of base (NaOH) used is equivalent to the total amount of exchangeable acidity ($H^+$+$Al^{3+)}$ in the aliquot taken (Odu *et al.,* 1986). The total sum of exchangeable bases ($Ca^{2+}$+$Mg^{2++}K^+$+$Na^+$) and total exchangeable acidity ($H^+$+$Al^{3+)}$ gave the effective cation exchangeable capacity (ECEC) (Juo, 1979). Percentage base saturation was calculated as the ratio between the sum of exchangeable bases and effective cation exchangeable capacity multiplied by 100.

**i.e. Base Saturation** = $\frac{Ca2+Mg2++K++Na+ \; x \; 100x^2}{ECEC}$ equ . (1)

*Statistical Analysis:* Data were statistically analyzed for variance (ANOVA), and significant means were compared using Duncan multiple range test. Paired t-test was used to compare means of the unburnt and burnt plots. For all tests, a threshold of $P < 0.05$ was used to define statistical significance.

## RESULTS AND DISCUSSION

The mean values of the physical and chemical parameters in burnt and unburnt plots are presented in Table 1. Table 2 is ANOVA for statistical variance of the burnt and un-burnt plots

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**Table 1**: The mean Soil quality parameters for burnt and un-burnt land at different soil depths in the study area

| Soil Indicators | Unburnt Plot | Burnt Plot | Unburnt Plot | Burnt Plot |
|---|---|---|---|---|
| | 0-15cm | 0.15cm | 15-30cm | 15-30cm |
| Soil pH ($H_2O$) | 5.58 | 7.2200 | 5.1200 | 6.3500 |
| Soil pH ( KCl) | 4.8633 | 6.5000 | 4.2467 | 5.8900 |
| Sand ($g.kg^{-1}$) | 73.01 | 67.2000 | 62.5333 | 64.5333 |
| Silt ($g.kg^{-1}$) | 8.0333 | 6.6667 | 8.0000 | 6.0000 |
| Clay ($g.kg^{-1}$) | 18.1333 | 26.1333 | 29.4667 | 29.4667 |
| Soil Organic Carbon (SOC) ($g.kg^{-1}$) | 2.3100 | 2.7333 | 1.5567 | 1.9633 |
| Soil Organic Matter (SOM ) ($g.kg^{-1}$) | 3.9933 | 4.7267 | 2.6967 | 3.5367 |
| Total Nitrogen (T N) ($g.kg^{-1}$) | 0.1967 | 0.6667 | 0.1300 | 0.7200 |
| Available Phosphorus ( Avail, P ) ($mg\ kg^{-1}$) | 2.5400 | 3.45 | 0.3133 | 1.4 |
| Calcium (Ca) ($cmol\ kg^{-1}$) | 2.5333 | 2.6667 | 2.5333 | 2.2667 |
| Magnesium (Mg) ($cmol\ kg^{-1}$) | 1.6000 | 1.9667 | 1.4667 | 1.7667 |
| Potassium (K) ($cmol\ kg^{-1}$) | 1.8567 | 0.5933 | 0.1333 | 0.6000 |
| Sodium ( Na) ($cmol\ kg^{-1}$) | 0.1300 | 0.1567 | 0.1633 | 0.2033 |
| Exchangeable cation (EC ) ($cmol\ kg^{-1}$) | 5.0200 | 5.3833 | 5.1633 | 4.8367 |
| Base saturation (Bs) (%) | 82.5667 | 82.2000 | 52.1633 | 82.8000 |

Results in Table 1 shows the mean values of the physical and chemical indicators of soil sampled from the unburnt and the burnt respectively at the different depths. Table 3 shows analysis of variance of the two plots in the study area

*Particle Size***:** From the result, the mean values of sand, silt, clay of the surface (0-15) and sub-surface (15-30) soil samples of an unburnt plot recorded73.2 % and 62.5%, 8%, 29.5% while that of the burnt plot recorded 67.2, 6.7, 26.1 % respectively . The decrease of silt in the burn plot was reported by Kattering et al (2000), which were served to be due to high temperature fussing the silt fractions hence reduction. The result also recorded an increase in the sand fraction of burn area due to an increase in temperature that lead to the breaking of the soil particles causing the soil to be coarse. The finding was consistent with the finding of Ulery et al (1993); the increase in the percentage of clay of the burn plot was due to fire severity that leads to the fusion of clay fractions in the soil.

*Soil pH***:** From the result in Table 1 at the depth of 0-15cm, the mean pH within the surface soil ranged between 5.58-7.2 with slash and unburnt farmland having a slight decrease in soil pH than slash and burnt with an increased value of neutrality. At the subsurface of 15-30cm, soil pH ranged between 5.12-6.4 as pH ($H_2O$) showing the same trend of the soil pH in surface soil in slashed and unburnt. The soil reaction of slashed and unburnt plot was extremely acidic to moderately acid and the burnt plots were moderately acid to neutral. The same trend was observed in pH (KCL) that ranged between pH4.9 - 5.9 (0-30cm) for slash and unburnt, pH5.9- 6.5 for slash and burnt respectively. This suggested ashes released during burning. The ash thus serves as liming and fertilizing material while reducing soil acidity (Adeyolanu *et al.* 2013). This increase in pH of slash and burn plots was essentially due to the production of K and Na oxides, hydroxides and carbonates immediately after burning (Arocene and Opio, 2003), also increased soil pH would increase the affinity of $Ca^{2+}$ for P and the potential for precipitation of Ca phosphate minerals during the fractionation procedure (Giardina, et al, 2000).

Burn-related increases in soil pH are due to the acid neutralizing capacity of ash (Khanna et al., 1994) and to consumption of hydrogen ions during the combustion of organic acids in soil and the forest floor.

*Soil organic carbon (SOC):* From the results in Table 1, soil organic carbon ranged between the mean value of 2.31-2.7 $g.kg^{-1}$ with burnt plot recording the highest value than slashed and not burnt at the surface of the soil, while the subsurface ranged between the mean value of 1.56-1.96 $g.kg$-$^{1}$ with the burnt plot having the highest mean value than slash and unburnt plot, suspected to be caused by leaching due to the sandy nature of the soil. This result negate the finding of Pyne and Goldammer (1997) who reported the loss of organic carbon in soil occurs as a result of fire depleting the litter on the surface, but supported by Edem and Alphonsus (20016) who observed increased in soil SOC in the soil surface after burning.

*Soil organic matter (SOM):* The soil organic matter increase structure stability, resistance to rainfall impact rate of infiltration and faunal activities (Ubuoh et al, 2016). From the results in Table1, the mean values of soil organic matter (SOM) ranged between 3.99-4.73 $g.kg^{-1}$ with burnt recording highest value at the surface and subsurface ranged between the mean of 2.70-3.54 $g.kg$-$^{1}$ with burnt plot having highest value (Table 1). The result is in consonant with the finding of Ubuoh et al (2016) who reported than among the selected land use types, bush burning increased the highest amount of SOM leading to an increase in soil fertility

*Total nitrogen (TN):* From the result in Table 1, surface and subsurface, the mean value of TN varied between 0.20-0.67 $kg^{-1}$ 0.13-0.72 $kg^{-1}$ with burnt plot at different depths having the highest mean values respectively. The result conforms to the finding of Edem and Alphonsus (2016) who observed increased in total nitrogen in burnt soil in in continuous cropped arable experimental plots. Availability of TN in the subsurface is suspected to be due to leaching. Accordingly, soil N is very sensitive to biological transformations, and to losses due to leaching, volatilization, oxidation and denitrification (Giardina et al, 2000).

*Available Phosphorus (Avail. P):* Result from Table 1 showed that available P. in the surface soils of both sampled plots at the depth of 0-15cm ranged between 2.5400-3.45 P mg $kg^{-1}$ with burnt plot recording the highest value than unburnt plot, while a the depth of 15-30cm in the two plot, Avail.P ranged between 0.3133- 1.4 P mg $kg^{-1}$ with slash and burnt having the highest value than slash not burnt. The result is consistent with the finding of Tabi et (2013) who observed increase in available P was higher immediately after burning than after one year of cropping relative to the unburned forest vegetation.. Serrasolsas and Khanna (1995b) reported a steady decline in phosphatase activity with increasing temperature, and a near complete loss of phosphatase activity in soils heated to 250 _C. Addition of wood ash also increases available P. Van Reuler and Janssen (1995) concluded in Cote D'Ivoire that increase in yield in slash and burn trials was mainly a P effect. Kopecky et al. (2012) reported that each ton of wood ash could substitute for 13 to 14 kg of phosphate ($P_2O_5$). Ubuoh et al (2012) reported that wood waste exerted appreciable influence on available phosphorus.

*Calcium( Ca)***:** From the result, at the depth of 0-15cm, calcium ranged between 2.53-2.76 cmol $kg^{-1}$ with burnt plot recording the highest value, while unburnt had the lowest value in the top soil. At the subsoil, calcium ranged between 2.27-2.53 cmol $kg^{-}1$ with unburnt soil having the highest value than burn soil. An increase of Ca in the subsoil of unburnt plot may not be due to leaching because calcium is present adequately in most soils and is a component of several primary and secondary minerals in the soil. Most soils are derived from limestone basement complex leading to an increase in calcium. Ultimately, a decrease in the calcium level of the burnt plot may be caused by environmental factor and could be removed by surface prevailing wind after burning of the plot (Goh and Philips, 1991).

*Magnesium (Mg):* The result of magnesium ranged between 1.6-2.0(cmol $kg^{-1}$) at the topsoil with burnt plot recording the highest value than unburnt. At the subsoil, the result ranged between 1.5-1.8(cmol $kg^{-1}$) with burnt having the highest concentration that subsoil accordingly. The increased in the burnt plot may be due to increase in organic matter of the soil with an increased pH level due to the present of ash which is supported by George et al(1994).

*Potassium (K)***:** It was observed that potassium in Table 2 ranged between 0.6-1.9(cmol $kg^{-1}$) with unburnt plot recording the highest value than burn plot at the topsoil. At the subsoil, the result ranged between 0.13-0.60(cmol $kg^{-1}$) with the burnt soil recording the highest value than unburnt. This variation could be due to environmental factors such as wind and rainfall which ploy major role in the sustainability of potassium. According to Ulery (1993), wind and rainfall play a role in the concentration of potassium, after burning in the burnt plot be removing it from the topsoil. An evident of this is seen in this result where the subsoil of the burnt plot has taken the lead.

*Sodium (NA):* From the result, sodium is observed to range between 0.13-0.16 cmol $kg^{-1}$ in the top soils of burnt and unburnt plots, at the subsoil Na ranged between 0.16-0.20 cmol $kg^{-1}$ with the burnt topsoil and subsoil having the highest value respectively. The result is at variant with the finding of Simard et al (2001) who observed that, the slight reduction in Na level in burnt area may be as a result of leaching since Na is weakly held by the soil colloid.

*Exchangeable Cation (EC):* The five most abundant exchangeable cations in the soil are calcium ($Ca^{++}$ ), magnesium ($Mg^{++}$), potassium ($K^{+}$), sodium ($Na^{+}$) and aluminium ($Al^{+++}$) .(Ubuoh et al, 2013). From the result from the traditional burning of the farmland at the depth of 0-15cm, EC ranged between 5.02-5.4 cmol $kg^{-1}$ with burnt plot recording the highest value and unburnt having low value. Accordingly, at the depth of 15-30cm, the result ranged between 4.83-5.2 cmol $kg^{-1,}$ with unburnt having the highest value and burnt having the lowest which is suspected to be due to leaching of the sandy soil in the site. The increase of EC in the topsoil of the burnt plot is consistent with the finding of Parkinson (1998). The increase may also be due to the deposit of ash in the burnt plot that increase the pH level of the soil which is supported by the finding of Kattering et al (2000).

*Base Saturation (BS):* Closely related to cation-exchange capacity is the base saturation (Bs), which is the fraction of exchangeable cations that are base cations (Ca, Mg, K and Na). It can be expressed as a percentage, and called percent base saturation. From the result, unburnt plot recorded Bs between 82.20-82.60% at topsoil with unburnt having the highest value, and subsurface having the mean values that ranged between52.16-82.80% with burnt having the highest value. The results implies that, the proportion of the cations occupied the burnt plot varied by various cations such as H, Ca, Mg and K, indicating that cations with one positive charge (H, K, Na) will occupy one negatively charged site and cations with two positively charge such as Ca and Mg occupy two sites on the burnt plot (Serraesolsasa and Khanna, 1995).

**Table 2:** ANOVA: Analysis of variance of burnt and unburnt plots

| Source of Variation | | Sum of Squares | df | Mean Square | F |
|---|---|---|---|---|---|
| | Between Groups | 19308.818 | 14 | 1379.201 | 5893275.389 |
| Unburnt plot | Within Groups | .004 | 15 | .000 | |
| | Total | 19308.821 | 29 | | |
| | Between Groups | 17983.498 | 14 | 1284.536 | 716976.765 |
| Burnt plot | Within Groups | .027 | 15 | .002 | |
| | Total | 17983.525 | 29 | | |

**At 0.05, critical $F_{Ftab}$ = 4.60 and calculated $F_{cal}$= 1.597Ω 1.6**

From Table 2, since F of 4.60 ≥ 1.6, HO is rejected. So soil quality among the two plots sampled (slash and burnt) and (slash and unburnt) are significantly different due to fire that is introduced to farmland that leads to increased and decreased in soil fertility. The conclusion therefore is that soil quality among the two sampled plots varies due to action of bush burning as a traditional method of land preparation in the study area.The farmers in the area should therefore choose the method of land preparation that is environmental friendly for soil sustainability to boost food production for the sustenance of the teeming population.

*Conclusion*: From the observation, cultural practice such as slash and burn method have both beneficial and detrimental effects on soil quality. From the study there was reduction in soil pH, decreased in in silt and increase in sand contents, increase in SOC, SOM, TN, and avail. P, Ca, Mg, K. Na, decrease in EC and BS respectively in the burnt plot under study. However differences were observed in the level of the soil indicators, the differences were statistical significant because farming in the area was intensive and continuous through the use of traditional land preparation method called "slash and burn.

*Recommendation*: Since slash and burn method for land preparation has been there from time immemorial, to stop will be very difficult until local farmers in the area are sanitized on the implications of slash and burn on soil ecosystem and environment as a whole. It therefore suggest for an effective environmental extension for greater awareness.

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